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Electrochemical and Metallurgical Industry

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Electrochemical and Metallurgical Industry

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Ourselves.

Glückauf—the old good-luck salutation of the German miner—we proffer with the compliments of the season to our readers and friends; and it also indicates our hopes for the continuous advance of this journal, under the new name it assumes with the present issue. Started in September, 1902, the purpose has consistently been to make the journal an authoritative exponent of electrochemical science and its various applications; and the steady increasing number of subscribers has proven not only that its pages have appealed strongly to those connected with the electrochemical and electrometallurgical industry and science, but also to the rapidly increasing number of progressive chemical and metallurgical engineers. Thus we found it necessary, almost from the beginning, to pass beyond the bounds of the strictly electrochemical field, and to take account of new chemical and metallurgical developments with which electrochemical processes may have to compete, or which may react in some essential way on that industry. An electrochemist is almost necessarily interested in all things new in the chemical field, and an electrometallurgist in all things new in the metallurgical field. Thus, a glance over the indexes of our first two volumes will show that we could not have served the highest interests of electrochemistry without touching on a host of developments purely chemical or purely metallurgical. What we therefore have done in enlarging the title of this journal has simply been to indicate formally what has already been the working policy of its editor and management in the past.

Any new process can be industrially successful only if products are obtained by its means more cheaply than by any other. The estimate of the value of a new process must, therefore, always be based on a comparison with existing methods, with an allowance for possible and probable improvements in the old methods. To judge and understand the industrial posibilities of an electrochemical or electrometallurgical proposition, it is absolutely necessary to canvass intimately the old chemical and metallurgical arts. The reverse is equally true, for the engineer who has applied purely chemical or metallurgical processes only, must always look out for possible improvements, and the greatest menace to his established methods of working is at present from the application of the electric current to chemical and metallurgical reactions—at least in certain final steps of operation. Our modern metallurgical and chemical plants have already networks of electric lines for lighting and power purposes, so that the application of electrical energy to chemical and metallurgical processes does not assume a revolutionary aspect. This, perhaps, explains why our journal has made friends far beyond the strictly elect[ro]chemical and electrometallurgical field and why it has found, apparently, its way to the desk of practically all pro-

gressive A[illegible] metallurgists. It is in metallurgy—in special problems w[illegible] the old metallurgical art has lacked in success—that electrochemical methods will probably find the largest application in the near future. Electrochemistry won its first great industrial laurels in the production of new compounds; a new electrochemical plant meant a new industry, like those of aluminium, calcium carbide, carborundum, artificial graphite, artificial emery, etc. While these industries show a steady and healthy development, important new developments are to be expected in future in certain stages in the production and treatment of ordinary metals—as, in the steel industry—and it becomes more clear from day to day that the progressive worker in these fields will have to be intimately acquainted with the old metallurgical art as well as with all the possibilities of electrical methods. To record carefully and analyze the highest position of the arts of to-day, and to do pioneer work for the art of to-morrow, will in the future, as in the past, be the programme of this journal, so far as its ability extends.

The development due to the introduction of electrochemical methods into metallurgy has, of course, proceeded for some time. The refining of copper is an old and firmly established industry; now we also have the refining of zinc, nickel, lead on a commercial scale. In all these cases it has taken time and experience to learn at what stage it was profitable to introduce electrolysis. Attempts have been repeatedly made with an anode of ore without success, until it was finally learned that the treatment of the copper from the mine up to the production of pure copper is best divided into a series of distinct steps, of which the first ones are all mechanical and metallurgical, and only the last purely electrolytic. One may specialize in one of these several steps, but it is impossible to cope with the entire subject without being familiar with metallurgical as well as with electrochemical methods.

Very instructive in this connection is the development of gold metallurgy in South Africa, characterized, as it has been, by a battle royal between zinc precipitation and electrolytic precipitation. It might be considered enough to discuss in an electrochemical journal simply electrolytic precipitation, but we have held to a broader view of the situation. What is wanted is the best method in any case, and according to the special conditions of the case, one or another method may be preferable. To understand the conditions which favor each method, is the question every gold metallurgist is after; and from this view-point we have covered the subject in the past year in various articles from most authoritative sources. It is quite interesting to refer in this connection to a note of Mr. Charles Butters, the pioneer of electrolytic gold precipitation in South Africa, who now employs in several plants a combined zinc and electrolytic precipitation process. But this example is also instructive in another aspect. We have repeatedly pointed out that zinc precipitation is essentially an electrochemical reaction, due to the great many very small short-circuited galvanic cells in the precipitating vat itself, resulting in the solution of zinc and the precipitation of gold. This also explains the success of the use of "couples" in other processes of zinc precipitation, especially in the case of the zinc-lead couple; the success of Betty's method of adding free cyanide at the head of the precipitation box in the zinc-lead couple process appears quite analogous to the addition of free acid to electrolytic refining or electroplating baths. This shows how knowledge of electrochemical methods and processes may be helpful in the explanation of purely metallurgical processes, and it suggests how this knowledge may assist the metallurgist in his work. In fact, the science of electrochemistry and of physical chemistry in general can be made a powerful tool for metallurgists. To present such knowledge in practical form will be, as heretofore, a special aim of this journal.

A technical journal, to fulfill its functions to the highest degree, must grow with the industry which it endeavors to serve and adapt itself to changing conditions. If the profession lends its aid, if the foremost men of industry and science contribute information to its columns, then, and then only, can the paper be of the highest service to the science and industry represented. For ourselves and our readers, we wish to express our appreciation to those who have contributed in the past to our columns, and with a sincere desire that in the future this journal may continue to merit the good wishes and the collaboration of all those who work in the field of electrochemistry or metallurgy, we renew our greeting, and trust that all of our readers will share in the benefits of the expanding arts in which they and we are all so deeply interested.

Metallurgy of Zinc.

In this issue we publish three articles on the metallurgy of zinc, two dealing with the production of zinc, the third with the use of zinc for coatings on iron. An able resumé of the present situation of zinc metallurgy is given by Dr. Franz Meyer, who is eminently qualified to speak on this subject, both through his connection with progressive metallurgical developments in this country and his former position as general manager of a German zinc company, which enjoys the reputation of being one of the most progressive and best-managed concerns in the field. Dr. Meyer's lucid exposition of the present situation of the industry and his critical discussion of the tendencies towards improvements are, therefore, based on an intimate acquaintance with the conditions and needs of the present art and should be accepted as the conclusions of a specialist who is both conservative and progressive. While at present it is probably more important to look forward towards improvements of details in the present methods, yet it is most interesting to note the activity along entirely new lines, especially in the attempts of introducing the blast furnace and the electric furnace into zinc metallurgy. Concerning the DeLaval electric zinc process, mentioned by Dr. Meyer, we understand that zinc made by this process has been sold for at least a year in Europe in competition with, and at the same price as, purest Vieille Montagne (Altenberg) zinc; the chief feature of the electric furnace zinc is its high purity, the content of lead being below 0.1 per cent. This is certainly a symptom favorable to the future of the electric furnace in the zinc industry, though it may be doubted

whether DeLaval's arc furnace represents really that design of electric furnace which is best adapted for zinc distillation. Mr. Woolsey McA. Johnson contributes to this issue an interesting article on a special problem of zinc distillation, that is the effect which sulphur compounds have on the reaction in the zinc retort. One special remark of Mr. Johnson is worthy of emphasis; he urges that in roasting the ore the object is to obtain an ore which will give the best results in the distillation furnace, not an ore which is especially low in sulphur. The correctness of this maxim is self-evident, yet the fact that a metallurgical process is generally a series of operations succeeding each other and carried out in different departments of the works, has too often caused the superintendent and engineer of one department to specialize in his own field and to lose sight of the whole problem. The best results in metallurgical art require co-operation of all departments, and planning the working field of each department so as to make the total efficiency of the whole works a maximum.

The third paper published on zinc in this issue, is Prof. C. F. Burgess' able article on the properties of zinc coatings. Zinc is very extensively used as a coating on iron for protection from corrosion; the coating is mostly applied by the hot dip and in comparatively rare cases only by electrolysis. An accurate comparison between the properties of the zinc coatings, obtained by these two methods, is the object of Prof. Burgess' paper. The methods of testing the coating are themselves extremely interesting; Prof. Burgess has worked out careful methods of testing the durability against corrosion, the adherence, the effect of heating and cooling, the toughness and strength of coatings, and the resistance to abrasion. The results obtained by these methods are equally interesting. Only with respect to one property—that is, the resistance to the effects of heating and cooling—electrolytic zinc seems inferior to the older form; in this case, the electrolytic zinc coating blisters. Where the material is to be heated—as for pipes leading from heating furnaces—it is therefore preferable to use a zinc coating obtained by the hot dip. On the other hand, with respect to some other properties, the electrolytic zinc coating is decidedly superior to the other form. Especially with regard to durability against corrosion, adherence and toughness, Prof. Burgess' tests reveal a remarkably favorable showing of electrolytic zinc coatings.

The results obtained by Prof. Burgess in careful tests with accurate methods are, indeed, so favorable to electrolytic zinc coatings in many respects that it would seem economical to use such coatings for various purposes to a greater extent that at present, in spite of the higher first cost. The results given in the article will enable one to specify in such cases what dimensions an electro-coating must have to be at its best. Prof. Burgess' article should be read with great attention by zinc platers, since it is suggestive with respect to possible improvements in plating solutions. Finally, in one point his results have a bearing on the theory of electroplating. It is often assumed that the adherence of zinc coatings on iron is due to an alloying; in fact, the formation of an alloy is sometimes considered to be a fundamental condition which must be fulfilled to obtain an adherent electro-coating. Prof. Burgess' adherence tests apparently indicate that no such alloying occurs between the zinc and iron, although the evidence to this effect does not seem conclusive, since the adherence between the two metals would undoubtedly depend on the thickness of the boundary layer of alloy and this thickness might be very small in the special case of a zinc coating on iron.

Electric Resistance Furnaces.

Besides descriptions of various types of electric furnaces and processes scattered through the volumes of periodical engineering literature, the only authoritative and compresive work on the subject of the electric furnace has been, up to the present, Moissan's classical book. The subject of the resistance furnace which is daily increasing in industrial importance, had never found adequate treatment. This vacancy is now being filled in an admirable way by the series of articles by Mr. FitzGerald, which was started in the September issue of our last volume. Mr. FitzGerald, whose long connection with the two most important electric resistance furnace industries qualifies him to speak authoritatively on the subject, has so far covered in his serial the following subjects. After a discussion of some first principles of electric resistance furnaces in the September issue, he dealt in the November issue with the use of silico-carbides, carborundum and carbon as refractory materials for furnace lining, and discussed in the December issue the materials suitable for resistors, especially granular carbon resistors; in an article in the present issue he discusses miscellaneous accessories, notably means for regulating the voltage and methods of electrode connections.

The term resistor, introduced by Mr. FitzGerald, appears to be a useful addition to our engineering vocabulary. Just as we distinguish between a conductor and its conductance, we should distinguish between the resistor—*i. e.*, the material—and its resistance. It would appear at first sight that the calculation and design of an electric resistance furnace would be an extremely simple problem, since the whole effect is the change of electrical energy into heat according to Joule's law. In view of the simplicity of this law, the problem would appear to be just as simple as, for instance, the calculation of the voltage loss along a transmission line, according to Ohm's law. However, there is one vital difference between the two cases. The resistance of the transmission line is practically constant during operation. But this is by no means the case with the resistor in a furnace, as forcibly brought out by Mr. FitzGerald in his article in our last issue. The resistance of the resistor may change enormously, and this results in the necessity of voltage regulation. In order to use the full available power throughout the furnace run, the maximum and minimum voltages attainable must have to each other the ratio of the square roots of the maximum and minimum resistances of a resistor. Thus, it is absolutely necessary to provide for means of regulating the voltage within considerable limits. Various practical means for this purpose are described by Mr. FitzGerald in his article in our present issue.

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American Electrochemical Society.

The next annual meeting of the American Electrochemical Society will be held in Boston, Mass. The date preliminarily fixed is April 25 to 27, but it may be necessary to hold the meeting a week earlier. Prof. W. H. Walker, of the Massachusetts Institute of Technology, is chairman of the local committee. The hotel headquarters will be at the Hotel Lenox, Boyleston and Exeter Streets, Boston.

At the November meeting of the Board of Directors the following gentlemen were elected members of the society: Francis X. Govers, Oswego, N. Y.; Y. Shingo, Tokyo, Japan; J. Sigfrid Edstrom, Vesteras, Sweden; Herman Schlundt, Columbia, Mo.; Geo. G. Grower, Ansonia, Conn.; E. H. Seaman, Wantagh, L. I., N. Y.; Birger Carlson, Mansbo, Avesta, Sweden; Ralph E. Myers, State College, Pa.; William Koehler, Cleveland, Ohio, and Arthur W. Burwell, Lakewood, Ohio.

At the December meeting of the Board of Directors the following gentlemen were elected members: I. Baum, Uniontown, Pa; F. Winteler, Buffalo, N. Y.

At the January meeting the names of the following gentlemen will come up for election: C. J. Thatcher, Brooklyn, N. Y.; J. R. Powell, Galesburg, Ill.; John Nelson, Peru, Ill.; Samuel W. Parr, Urbana, Ill.; Sigmund Saxe, New York; Edward Wray, Madison, Wis.

Electric Steel Furnaces in Europe.

In an editorial on The Canadian Commission Report on European Electric Iron and Steel Furnaces, we remarked that "there is at least one electric furnace process—that of Girod—making special steels on a commercial scale not mentioned in the report." We are informed by Dr. E. Haanel that the French company operating Girod's process makes only ferro-alloys on a large scale and has given up the intention of making steel.

Our remark was based on the fact that the exhibit of the company at the St. Louis exhibition contained besides various ferro-alloys, also tungsten steel and vanadium steel.

Noble Prizes.

The awards of the Noble prizes have now been published. That for physics has been awarded to the Right Hon. Lord Rayleigh, F. R. S., and that for chemistry to Sir William Ramsey. The distribution of the prizes took place on Saturday, Dec. 10, in the great hall of the Academy of Music, Stockholm, in the presence of King Oscar. A banquet followed, at which nearly 200 guests were present. It was stated in the *London Times* that Lord Rayleigh intends to present the value of his prize to Cambridge University. The sum of money attaching to each Noble prize is about $39,000.

News and Notes.

Slimes.—An editorial discussion of the definition of the term slime from the metallurgical standpoint, in the *Engineering and Mining Journal*, of December 22, arrives at the result that slime is an unclassified impalpable mud which it is difficult to decant or to leach.

Worcester Chemical Club.—At a recent meeting of the Worcester (Mass.) Chemical Club, held in the chemical laboratory of the Worcester Polytechnic Institute, Prof. J. H. Perry presented a paper on the chemical composition of rocks, and the importance of this study in showing the manner of their origin. Most interesting material for such a study is to be found in the various granites abounding in Worcester County. The author stated that this study has already led to an entirely new classification of the igneous rocks, based on chemical analysis and not on structure, texture or mineral constituents. B. B. Wright then spoke on the equivalence of the six hydrogen atoms in the benzene molecule. There was also some discussion on the manufacture of carbon tetrachloride and on the purification of water by ozone.

Institute Annual Dinner.—The annual dinner of the American Institute of Electrical Engineers will be given in the ballroom of the Waldorf-Astoria, New York City, on February 8, and promises to be a most interesting occasion. In view of the recent opening of the Subway, and the adoption of electric traction on some parts of the New York Central, the Pennsylvania and the Long Island Railroad, the Institute has decided to devote this dinner to emphasizing the triumph of electric traction. A number of pioneers and leaders will be present, an original menu has been designed, and some novel features will be introduced, while the list of speakers includes men of national and international reputation. The dinner will be served for $5 per cover, without wine or cigars, and, as is usual on these occasions, ladies will be present. The participation of the ladies was a feature that elicited Mr. Carnegie's enthusiastic commendation at the famous Institute Library dinner, which he made forever memorable by his million-dollar gift for the United Engineering Building.

Polytechnic Institue of Brooklyn.—The College of Arts and Engineering of the Polytechnic Institute, of Brooklyn, has arranged evening courses in chemistry and electrical engineering, for which eminent chemists and electrical engineers have been appointed. Dr. Fred W. Atkinson is the president of the Polytechnic Institute, Dr. Samuel Sheldon the department chief and professor of physics and electrical engineering, Dr. J. W. Fay professor of chemistry. The subjects of the courses to be held by the consulting professors are as follows: G. C. Whipple on sanitary and industrial water supply; A. C. Langmuir on shellac, varnishes and glycerine; H. W. Wiley on foods and their adulteration; William McMurtrie on general technical chemistry; C. F. Scott on commercial electrical engineering; F. A. C. Perrine on electrical power transmission; W. S. Barstow on central station practice; T. D. Lockwood on telephony, telegraphy and patent practice; Louis Duncan on electric traction. Admission will be free to all undergraduate students of the Polytechnic, while others interested in the subject may attend for a fee which varies according to the length of the courses.

Phosphate Fertilizers.

An interesting paper on the sources of supply and methods of manufacture of phosphates and potash salts was presented on December 15, before the Franklin Institute of Philadelphia, by Professor E. B. Voorhees, director of the New Jersey Agricultural Experiment Station in New Brunswick. The paper was fully illustrated by a great many lantern slides, so that without the aid of illustrations it is somewhat difficult to do justice to the paper in a brief abstract. However, the following summary giving the gist of Professor Voorhees' address should be welcome to our readers, since electrochemical methods have repeatedly been made use of for the production of phosphate fertilizers, (for instance in Palmaer's method, Electrochemical Industry, Vol. II., page 470).

Of the mineral elements required by plants, phosphorus and potassium are of the greatest importance. The term "soil exhaustion" means the exhaustion primarily of these constituents rather than any of the other minerals that plants seed. In the crops of cereals, hay, flax and cotton, grown in this country, there are removed from the soils annually phosphoric acid equivalent to about 7,000,000 tons of superphosphate, containing 14 per cent. of phosphoric acid, and an equivalent of 2,500,000 ton of muriate of potash containing 50 per cent. of actual potash. Phosphates useful for the purpose of the manufacturing of fertilizers are obtained from two sources, organic and mineral; organic phosphates consist chiefly of animal bone; this phosphate has been in use from very early times, though it is only within the last century that it has been used in a rational way. The very good results derived from the use of bone, both raw and dissolved, have encouraged its wide use, and often in preference to the phosphates from

mineral sources. Mineral phosphates, first discovered in England in 1845, were called "coprolites." Other deposits have been found since in various part of Europe and other countries, notably the "Bordeaux phosphates" in France; "phosphorites" in Spain; "apatites" in Norway; "phosphatic guanos" in the West and East Indies, and the Islands of the Sea, and deposits of greater or less value in Japan and Algeria; in fact in nearly every country of the globe are found deposits of phosphates useful in the manufacture of fertilizers.

Nevertheless, the most abundant and the richest deposits are found in America, and mainly in the United States. The deposits of apatite in Canada, of purely mineral origin and discovered in 1867, for a time served as a considerable source of supply, but owing to the difficulties in mining and the expense of separating and handling the phosphates, the output, notwithstanding its high quality, has rapidly declined since 1884. The South Carolina deposits near Beaufort, South Carolina, first exploited in 1867, and continuously worked since; the Florida deposits discovered in 1888, and the extensive Tennessee phosphates discovered in 1893, have been rapidly developed, and are now the chief sources of supply of phosphates of the finest quality. These deposits are not only extensive, but are easy to work, particularly those of Tennessee, and especially well adapted for the manufacture of superphosphates.

The various phosphates, both organic and mineral, are in their natural condition insoluble and thus are not in a condition to quickly supply the needs of plants nor to meet all the conditions of cropping. Investigations have revealed, however, that for many crops and under many conditions the organic phosphates as animal bone and the mineral phosphates when finely ground, do serve to supply the phosphoric acid rapidly enough to meet all demands. When such is the case the necessity for further treatment is not apparent, though because these conditions are limited, it is not likely that a very large demand will be made for phosphates in their insoluble form, and the only treatment of which is their fine subdivision.

Very early in the history of their use, therefore, studies were made of methods of treatment which would change the insoluble and slowly available phosphates into more quickly available forms, and it was found by treating phosphate of lime, tri-calcic phosphate, with sulfuric acid, that the reaction resulted in forming a mono-calcic or soluble phosphate and sulphate of lime. This treated product is the superphosphate of commerce. At present, therefore, a large portion of the organic phosphates, and practically all of the mineral phosphates are charged into superphosphates before being applied to the land.

The value of a phosphate when used in its natural state is based chiefly upon its content of phosphoric acid, but the value of a phosphate for the manufacture of a superphosphate depends both upon the amount of phosphoric acid contained in it and the amount and kind of other constituents associated with it. Phosphates which contain considerable amounts of iron and alumina are not well adapted for the manufacture of superphosphates, and no method has yet been perfected which will convert these products into as valuable superphosphates as those derived from phosphates containing minimum amounts of the foreign minerals. Various methods of treatment of phosphates unsuitable for superphosphates have been used which, while not making them as valuable under all conditions as superphosphates, materially increase the availability of the phosphoric acid. Still these phosphates are better adapted for use as phosphates than as constituent parts of a manufactured fertilizer, of which superphosphates or acid phosphate now constitute nearly one-half the total weight.

A prejudice existed for a long time against superphosphates because it was believed that they contained free acid and would thus injure the land. This has now largely passed away, though this feeling, together with the fact that the continual application of superphosphates without proper association with other substances does have a tendency to change the physical character, and to some extent the chemical character of soils, has given rise to the demand for neutral phosphates, those in which there can be no possibility of acid being present. These, however, have not yet been perfected, and the chances are that a broader knowledge of the composition and methods of use of superphosphates will rather encourage their use than increase the demand for products of another sort.

CORRESPONDENCE.

Materials for Resistors-Kryptol.

To THE EDITOR OF ELECTROCHEMICAL AND METALLURGICAL INDUSTRY:

Sir—Since writing the article on "Materials for Resistors," which appeared in ELECTROCHEMICAL INDUSTRY, December, 1904, a new "incandescent electric material," designed for use as a resistor and called "Kryptol," had been examined, and a note on the subject may be of interest.

The specimen purchased for inspection was found to be in the form of black grains of uniform size. The grains would mostly pass through a screen having 18 meshes to the linear inch and remain on a screen of 24 meshes to the inch. The grains had a dull appearance that did not suggest the presence of graphite; but when a specimen was heated in an open crucible the amorphous carbon present burnt away more rapidly than the graphite and the presence of the latter thus revealed. As it is not possible to determine by mere inspection whether a specimen of carbon is in the graphitic state or not, a sample was heated with a mixture of nitric acid and potassium chlorate which showed clearly that amorphous carbon was present. A sample of "kryptol" was heated in an open crucible till all the carbon was burnt and the residual ash, reddish in color and apparently consisting principally of ferric oxide, was weighed. The ash amounted to 0.24 per cent.

It is not possible from the examination of the "kryptol" to infer with certainty the method of manufacture; but probably it is formed by mixing graphite and some form of amorphous carbon, such as lamp black, with a liquid binder, baking, grinding the resulting material and grading carefully.

The manufacture of this material is founded in a patent granted to Dr. August Voelker* and a critical examination of the specification will serve admirably to bring out clearly some of the misconceptions connected with the use of granular carbon resistors and at the same time to emphasize the principles on which resistors are constructed.

A supposed non-recognition of the obvious fact that in using a granular carbon resistor the resistivity of the mass varies with the size of the grains is the basis of the patent. It is scarcely necessary to point out to anyone familiar with the use of granular carbon as a resistor that the necessity of grading the particles of carbon used in order to meet the various conditions of the work, has been fully recognized for many years. The equally obvious fact that the resistance of the resistor can be varied by a judicious choice in the selection of components having various resistivities, has also been well known for a long time. But Dr. Voelker has apparently discovered a remarkable law connecting volts with the size of carbon granules, so that a "thorough utilization of the electrical energy" may be obtained. The assertion is made that "for currents of two hundred volts and more * * * only grains of from three to seven millimeters can be employed." Five main groups of granular carbon may be formed; for currents of 200 to 300 volts, grains of 3 millimeters; for 300 to 400 volts, grains of 4 millimeters and so on. In short, the law might be expressed, according to Dr. Voelker's figures, as follows. In using granular carbon as a resistor for voltages of

* United States Patent 770,991; Sept. 27, 1904.

100 n — 100 to 100 n volts the proper diameter of the carbon grains is n millimeters.

Unfortunately for this remarkable law the heating effect of a current is a junction of the product of volts and amperes; but there is nothing said about amperes, size of resistor, heating surface, etc., and that there is any subtle law connecting the "thorough utilization of the electrical energy," the volts and the size of the carbon grains, is difficult to believe.

If it has been found by experiment that in order to heat a certain furnace to a definite temperature a current of E volts and I amperes is required then in order always to obtain the same temperature the following equation must hold:

$$EI = K$$

where K is a constant. If the resistance of the resistor is R ohms, then

$$I = \frac{E}{R}$$

and substituting in (1)

$$\frac{E^2}{R} = K$$

whence

$$R = \frac{E^2}{K}.$$

This means, under the conditions described, that the resistance of the resistor must be varied as the square of the voltage. This condition must be fulfilled, and this cannot be done so simply as Dr. Voelker's patent would assert. The study of graular carbon resistors shows the number of factors which determine the resultant resistance.

The specification also errs in omitting the consideration of the effect of temperature on the resistance material. If silicates are present, then at high temperatures carbides will be formed and the resistance of the mass will be changed. At the highest temperatures there will be a marked permanent change in the resistivity of the amorphous carbon, thus causing a change in the resistance of the mass which will reach a maximum when the carbon is converted into graphite.

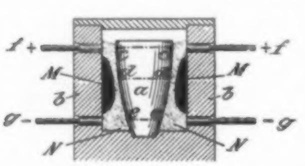


ILLUSTRATION FROM DR. VOELKER'S PATENT.

(M is a "material so compounded that it does not allow the current to pass at all, or only a very limited portion of it," while N is a granular material which conducts the current.)

Finally, in the drawing which accompanies the patent, wrong impressions are conveyed. It is correctly asserted that the maximum generation of heat should occur at *cc*; but as shown in the figure the maximum generation of heat would occur at *d d*, for at this point the cross-section of the resistor is least, consequently the resistance of this section is highest, and the heat generated per second will be greatest.

It is not intended to criticise "kryptol" as a resistor material in this note, nor to criticise adversely the importance of grading granular carbon carefully when using it as a resistor. The object merely is to call attention to the misleading impressions which are conveyed by the patent specification and may cause the inexperienced experimenter much trouble and waste of time.

F. A. J. FitzGerald.

Niagara Falls, N. Y.

Electrolytic Production of Phosphate Fertilizers.

To The Editor of Electrochemical and Metallurgical Industry:

Sir—With respect to the article on my electrolytic process for producing bicalcic phosphate in your issue of November, 1904, page 470, I would like to make the following remarks.

It is said in the article: "The raw material must be sufficiently pulverized, so that no grains of phosphate are embedded in silicates or other insoluble minerals." This is true, of course, but on the other hand, it is quite a merit of the method that in general the raw phosphate does not need to be reduced to a finely powdered state, as is always necessary in the manufacture of superphosphate. It is a fact that raw phosphate has been used in lumps of a diameter of as much as 5 cm.

"The capital needed amounts to about $65.00 per e. h. p. used in the manufacture, etc." (page 471). This sum includes not only the first cost of installation for the plant, but also the working capital; but the cost of installation for the electric power plant is not included.

Wilhelm Palmaer.

Stockholm, Sweden.

Proposed Combination of Massachusetts Institute of Technology with Harvard University.

To the Editor of Electrochemical and Metallurgical Industry:

Sir—In connection with the proposed combination of the Massachusetts Institute of Technology with Harvard University, the following authoritative statement of foreign opinion (translated from *Zeitschrift des Vereines deutscher Ingenieure* of Sept. 24, 1904) is of interest:

"At a meeting of the Union of German Engineers, held at Munich September 12, with the participation of thirty eminent representatives of technological schools and universities, as well as of other schools, and of industries, the following resolutions were adopted:

"1. It is not advisable, so far as can be foreseen, to attempt to meet the need of new technological schools by the addition of technological faculties to universities, but rather by the establishment of independent institutions; for the technological schools would be hindered in their independent development by attaching them to universities. This separation should not, however, impede the welcome development of intellectual good will between the two institutions. The attachment to universities would also in no way involve economies of consequence.

"2. The Union of German Engineers stands now, as before, by its expression of 1886, as follows:

"'We declare that the German engineers have the same needs and will be subjected to the same judgment as to their general culture as the representatives of other professions based on higher scientific education.'

"In this view we rejoice as the conviction more and more gains ground that a considerably greater significance is to be attributed than before to mathematical and natural science as a means of culture. Knowledge of these branches is becoming more and more an indispensable constituent of general education. The predominantly linguistic education now received by the majority of our gymnasium graduates does not satisfy the demands which must be made on the leading classes of our people, in particular, in respect to the increasing significance of economic questions."

Tech Graduate.

Boston, Mass.

[It is questionable if the conditions upon which the German opinion quoted is based, apply to higher educational conditions in this country. Abroad, and in Germany, particularly, a great gap has too long existed between the spirit of the old university and that of the modern technological school. Here, on the contrary, our universities have always been eager to extend their curriculum to meet the requirements of the engineering profession. It would appear that both the Massachusetts Institute of Technology and Harvard University would be benefited by a working arrangement whereby the more purely technical studies would be pursued in the former, and the more purely scientific branches, as well as general culture studies, in the latter.—Ed.]

Review of the Zinc Industry.

By FRANZ MEYER, PH. D.

The zinc industry has during the last year kept up its reputation of being the most conservative of all metallurgical arts. No inventions of a revolutionizing character have been made. Improvements of minor importance have been introduced or recommended, and the present state of this industry is briefly as follows:

ORES.

Due to the introduction of magnetic separation, and especially of the WETHERILL PROCESS, a great many ores and products of wet separation which, on account of their low zinc contents and their high percentage of impurities, were heretofore not available as zinc ores, are now advantageously used for the manufacture of spelter.

Whether the introduction of the BLAKE-MORSCHER electrostatic separator[1] will add to these concentrates remains to be proven. A plant equipped with BLAKE-MORSCHER separators, and which was put to work in Wisconsin has been closed again; the reason given for it is the small output in marketable product.

There is, however, a field for an electrostatic separator which will separate rosin blende from pyrites in a raw state, as the magnetic separators do not solve this problem. If the blende is in the form of "black jack," that is to say, if it contains chemically-combined iron, it can be separated from pyrites, without roasting, by the Wetherill process, but if it is in the form of rosin blende, it is not magnetic, and in order to separate it from pyrites the ore must be partly roasted so as to render the pyrites magnetic. This does not only add to the cost of separation, but it is also objectionable from the zinc smelter's standpoint, as a partly roasted blende requires more fuel in roasting than a raw blende, and as the gases from roasting such a material are, on account of their low contents of SO_2, not desirable for acid-making. For these reasons it is to be hoped that the electrostatic separators will soon be so perfected that they can be used commercially on this class of zinc ores.

But even without this, there is no fear that there will be a scarcity of zinc ores in the near future. According to a recent publication of F. H. Bathurst[2], the Barrier mines in Australia, which are famous as lead producers, will soon come to the front as large producers of zinc ores.

The process[3] invented by G. D. DELPRAT, the general manager of the largest of these enterprises, the Broken Hill Proprietary Company, is said to be an entire success for the concentration of the tailings of these mines. His method of separation consists in subjecting the tailings to the action of a heated aqueous solution of an acid, the density of which has been increased by the addition of a suitable substance. By the action of the acid on the sulphides, hydrogensulphide is developed, which gas carries the ore particles to the surface, whence they are removed, while the gangue falls to the bottom of the spitzkastenlike vat, in which the process is carried out.

As the apparatus is simple, the chemicals used, nitre cake or salt cake and sulphuric acid, are cheap, and as the Barrier Companies have huge heaps of these tailings on the surface, it is to be expected that the introduction of the Delprat process on a large scale will be the source of large quantities of low grade blende for the next years.

ROASTING.

While by most of the European zinc smelters the roasting gases are utilized for the manufacture of acid—both sulphuric and anhydrous liquid sulphurous—in this country, by far the largest part of these gases still goes to waste. This difference in the operations is partly due to the fact that in many European countries the law compels the smelters to remove the obnoxious SO_2 from the roasting gases before they are discharged into the air, partly to the unfavorable conditions for the sale of acid in many parts of the United States. Consequently, in this country, reverberatory kilns are mostly used, while in Europe, muffle furnaces are in almost general use.

These furnaces are, with a very few exceptions, rabbled by hand, while on account of the higher cost for labor in the United States the kilns are usually of the mechanically-stirred type. Of the reverberatory furnaces the BROWN and the ROPP types are mostly employed, while the only type of mechanically-rabbled muffle furnace which is in use in this country is the HEGELER furnace.

The works which employ the Hegeler furnace, viz.: the Matthiessen & Hegeler Zinc Co., the Illinois Zinc Company, the United Zinc and Chemical Company, the Mineral Point Zinc Company, the Graselli Chemical Company and the United States Zinc Company, utilize the roasting gases for making sulphuric acid, with the only exception of the last named concern, who have no market for acid, but who are, nevertheless, roasting all of their ore in muffle furnaces, on account of the higher losses in zinc if blende is roasted in reverberatory kilns.

The newer designs of mechanically stirred muffle furnaces belong more or less to the MacDougal type. A. R. MEYER[4] and O. HOFFMANN[5] propose to muffle the three lower hearths of a MacDougall furnace, 7 hearths high. There is no doubt that these kilns, if properly constructed, will roast blende down as low as the Hegeler furnace does, but the fuel consumption in them will be excessively high, as the passage which the gases of combustion make is too short to utilize their heat to the best advantage.

This loss of heat is avoided by F. MEYER's[6] construction, who intends to heat the two lower hearths of a series of kilns built according to the MacDougall type from one fireplace, common to the whole series. By this arrangement the gases of combustion are allowed to travel the same distance, which is known in the best practice of hand-worked muffle furnaces as the most economical for fuel consumption.

F. J. FALDING's[7] mechanically-stirred muffle kiln, which differs from the three furnaces just mentioned regarding the transportation of the ore, was tried by the Mineral Point Zinc Company, but it is not in use any more. The constructions of A. R. Meyer, O. Hoffmann and of F. Meyer have not yet been tested in practice, as far as it is known.

The five concerns who are manufacturing sulphuric acid from blende roasting gases in the United States, use the chamber process with the exception of the Mineral Point Zinc Company, who are working assording to SCHROEDER's[8] contact process, which was invented and developed at the works of the Actien Gesellschaft fuer Zink Industrie, vormals Wilhelm Grillo, in Oberhausen (Rhine), and the rights of which, in this country, are owned by the New Jersey Zinc Company.

SMELTING.

For reducing zinc oxide to spelter it is of great importance that the oxidized ore is intimately mixed with the reducing carbon. This mixing was formerly done by hand; nowadays it is performed by machinery, at least, in the up-to-date plants. In Germany and also in Belgium, the VAPART MILL which has also been installed at the most modern zinc smelter in this country, the United States Zinc Company, in Pueblo, Colorado, is used for this purpose with great success.

Still more important is the use of the very best refractory material obtainable for the construction of the furnace, and especially of the retorts.

An ideal zinc retort should have the following properties.

[1] U. S. Patents Nos. 668,791-2; Engineering and Mining Journal, Jan. 24, 1903, p. 146; ELECTROCHEMICAL INDUSTRY, Vol. I., 1903, p. 255.

[2] Engineering and Mining Journal, of Dec. 1, 1904, p. 871.

[3] U. S. Patents Nos. 763,662 and 768,035.

[4] U. S. Patent No. 750,877.

[5] U. S. Patent No. 768,748; ELECTROCHEMICAL INDUSTRY, Vol. II., p. 430.

[6] U. S. Patents Nos. 731,114 and 761,691; Metallurgie, 1904, p. 456.

[7] U. S. Patent No. 756,485.

[8] U. S. Patents Nos. 636,924 and 636,925; Journal of the Society of Chemical Industry, of 1903, page 348; ELECTROCHEMICAL INDUSTRY, Vol. II.,, 1904, p. 348.

Its exterior should stand the combined action of an oxidizing flame and of the fluedust of the coal, while its interior should resist the influence of a reducing atmosphere, of zinc and lead vapors, of the fused gangue, especially of ferrous oxide, and not seldom of metallic iron, at a temperature of 1,300° C. At the same time it should be a good heat conductor while it should not absorb any zinc, nor be penetrated by zinc vapors, and last, but not least, it should be available at a reasonable price. Many of these qualities are found in retorts made from silicium carbide (amorphus carborundum[9]) or ciloxicon[10], but the fact that the price of the product is so high, and that the articles made therefrom are attacked by an oxidizing flame at high temperatures, are still preventing their use. It is, however, to be hoped that the latter difficulty will be overcome, and that then the many direct and indirect savings effected by their longer life will warrant their introduction even at their comparatively high cost.

The clay retorts now in general use have been steadily improved, so that in well-managed plants an average life of the retorts of from 6 to 8 weeks is secured. This good result is greatly due to the use of C. Mehler's hydraulic retort press, by which the retorts are made in one operation and in one piece, thus doing away with the seam between the bottom and the cylinder.

The furnaces are either direct fired, or they are heated by natural or producer gas. The direct-fired furnaces, which usually are equipped with 5 rows of retorts of the Belgian type, are constantly replaced by gas-heated furnaces of the Rhenish-Belgian type, which, as a rule, have only 3 rows of retorts of a size between that of the Belgian and the old Silesian retorts. In these furnaces the air, or sometimes both the air and the gas are preheated by either the recuperative or the regenerative system.

As there are rumors[11] that the natural gas in the Iola district will not last much longer, this type of furnace will be, in all probability, also the general one in this country before long, if new gas fields are not discovered.

Of the most recent propositions to reduce zinc ores to metallic zinc in a shaft furnace the following may be mentioned:

John Armstrong[12] has designed a shaft furnace, of which the part above the exit for the zinc vapors consist of two or more compartments separated from each other by vertical partition walls. The center compartment takes the charge, while the lateral chambers are filled with anthracite or coke, so that the charge going down in the shaft is always surrounded by highly heated fuel, which is to reduce the Co_2 formed by the action of CO on ZnO again to CO and thus prevent the vapors of metallic zinc from reoxydizing. It is not known whether this furnace has ever been put into operation, but it is to be feared that its product will be a mixture of zinc dust (blue powder) and of zinc oxyde instead of spelter.

Paul Schmieder[13] proposes the use of a shaft furnace, the upper part of which is externally heated by producer gas, while into its lower part wind is blown. The products, made in the two parts, and which will be chiefly spelter in the upper part and impure zinc oxyde in the lower one, are caught separately. There is no doubt that the residue from this furnace will be lower in zinc than that from the ordinary zinc retort, but as the shaft can only be made of a small diameter, in order to raise the central part of the charge to the temperature of distillation, without injuring the walls between the shaft and the heating chambers by overheating, the furnace will hardly prove to be practicable.

The same must be said about F. Kellermann's[14] smelting furnace. This inventor proposes to treat a charge consisting of the ore, the reducing coal and a flux, without the aid of wind, in a shaft 4 feet x 16 inches x 5 feet high. The external heating of the shaft by means of producer gas necessitates the use of very thin and consequently delicate walls between the shaft and the heating chambers in order to get the heat through them.

W. C. Wetherill[15] tries to overcome the difficulty of heating the charge in a shaft furnace uniformly, by placing rows of horizontal heating chambers arranged one above the other in the furnace, thus dividing the charge into several vertical narrow sections. The furnace resembles an ordinary zinc furnace, in which the spaces between the retorts are filled with the charge, while the heating gases pass through the retorts. As the walls of the heating chambers must be thin for the reasons given above, a great drawback in this furnace is the fractability of these chambers, which will probably render the use of this furnace, which otherwise has some very good features, impracticable.

As it will soon be tried at the works of the Prime Western Spelter Company, it is to be expected that the results of this trial will be learned during this year.

On a principle entirely different from those above, E. Lungwitz's[16] process of treating zinc ores in a shaft furnace is based. This inventor recommends to place the shaft under a pressure of about 45 pounds per square inch, in order to recover the zinc in a liquid state in the furnace. The method offers many advantages from a theoretical standpoint; the practical difficulties which will have to be overcome in operating a blast furnace under such high pressure are, however, considerable.

The process will be tried on a large scale during this year, and it will be of interest to all zinc smelters to watch the results of this experiment.

Oskar Nagel, in his United States Patent No. 699,969, proposes a process for producing spelter in a blast furnace which consists in subjecting a suitable zinc ore, preferably mixed with coal, to the action "of water gas which is practically free from inert, indifferent and oxidizing gases, and by which the zinc will be reduced and as an evolved vapor will be condensed in an atmosphere which permits the formation of pure spelter." Nagel explains the failure which all prior attempts to produce spelter in a blast furnace have met with by the presence of these indifferent and oxidizing gases, such as, *e. g.*, nitrogen and carbon-dioxide, which, according to his experience, will in every instance cause the zinc vapors to condense to dust and zinc oxide instead of the liquid spelter.

While in this patent the inventor lays great stress upon the absence of these gases, in his later United States patent[17] No. 766,279, in which he proposes the use of hydrocarbons, and especially of natural gas, containing about 85 per cent. methane and 15 per cent. nitrogen, he states that this mixture is about equal to water gas, and that the nitrogen will do no harm to his process.

Nagel's process is now tried on a large scale by the Actien Gesellschaft fuer Zink Industrie, vormals Wilhelm Grillo in Hamborn, but according to a private communication from the inventor, these experiments have not yet advanced far enough to allow a conclusive opinion on the value of the invention.

In this connection it seems timely to recall a similar process described in Gustaf M. Westman's United States patent No. 383,202, of May 22, 1888. This inventor claims a "process of reducing zinc ores, consisting of subjecting the zinc ores in mixture with coal to the action of highly heated carbonic-oxide, and subsequently reheating and returning the gas through the charge." In the specifications he further states that he avoids the admixture of air or oxygen with the gas, that the solid carbon mixed with the zinc ore acts as the reducing agent, and that the only object of the carbonic oxide gas is to introduce from the outside the heat necessary to the

[9] Benjamin Talbot's U. S. Patent No. 628,288.
[10] E. G. Acheson's U. S. Patent No. 722,793; Electrochemical Industry, Vol. I., p. 287.
[11] W. R. Ingalls, in Metallurgie, 1904, p. 330.
[12] German Patent No. 132,139.
[13] German Patent Application Kl. 40a, Sch. 18,544.
[14] Berg-und Huettenmannische Zeitung, 1904, p. 369.
[15] Belgian Patent No. 168,010.
[16] U. S. Patents Nos. 538,786 and 565,961.
[17] Electrochemical Industry, Vol. II., 1904, p. 366.

reducing operation, and finally that the gas should be absolutely free from oxidizing matters.

This process was tried years ago in some place in New Jersey[18], but it is no longer in operation.

Of the many *electric processes* for the manufacture of spelter only two may be mentioned which are in actual operation. C. G. P. DE LAVAL[19] subjects a mixture of preferably finely ground ore and of finely pulverized carbon formed in a pile in a furnace chamber to the action of radiant electric heat upon a sloping surface of said pile, and conducting away and condensing the metallic vapor generated at said surface.

This process which is in operation in Sweden has the advantage that it is carried out in a simple apparatus, and that the electrodes probably have a long life as they come into contact with the metallic vapor only, and not with the charge directly. As, however, only the radiant heat is made use of, it can be worked advantageously only where cheap power is available.

C. HOEPFNER'S[20] process is in operation at the works of Brunner, Mond & Company, in England, for the manufacture of pure zinc which is guaranteed to be over 99.9 per cent. pure, and which is sold in competition to the Sterling zinc, made from the New Jersey Zinc Company's willemite in retorts. What kind of raw material, whether ores or scrap (hard zinc from the galvanizer?) Brunner, Mond & Company use is not known. A plant which was installed by the late Hoepfner at Fuerfurt-on-the-Lahn, Germany, does not produce spelter any more, but it has been changed into a lithopone factory. At these works it was intended to work the cinders of the zinciferous pyrites from Siegen, which are used by German manufacturers for the production of sulphuric acid. These cinders were subjected to a chloridizing roast, the roasted ore was leached with water, the solution was, after settling, freed from the glaubersalt formed in roasting by crystallization, and from the iron and manganese by precipitation. The remaining pure zinc chloride solution was electrolysed, using revolving annular zinc cathodes on which the pure zinc was deposited in a dense form. The chloride evolved on the anodes was used for the manufacture of bleaching powder.

ZINC DUST (BLUE POWDER).

This product which is mainly formed in the first period of distillation is a by-product with the European smelters, who use sheet-iron "prolongs" on the condensers to collect it. It contains from 85 to 93 per cent. metallic zinc; the rest is chiefly zinc oxide. As it is used as a strong reducing agent in indigo-dying and in the manufacture of organic products, it is valued according to it contents of metallic zinc.

In this country where the prolongs are not used, it is manufactured purposely and in special furnaces by the New Jersey Zinc Company according to Convers' and DeSaulles process.[21] Same is carried out in an "apparatus comprising a zinc-distilling muffle, a furnace for heating the same externally, and a collecting and expansion chamber immediately adjacent to the muffle and of such relative size and capacity as to be kept heated by the zinc vapors, and to precipitate said vapors therein in their substantial entirety as zinc dust." As the zinc oxide formed at the beginning and at the end of the operation is caught separately in a sheet-iron cone, the blue powder is very high in metallic zinc.

ZINC WHITE.

The bulk of this paint is in this country made directly from ores on the Wetherill grate, franklinite, a product from the magnetic separation of the New Jersey Zinc Company's Franklin Furnace ores, and roasted blende being the chief raw materials.

In Europe this process is not in operation, due to the lack of cheap anthracite coal; all European zinc white being made from metallic zinc, mainly from hard zinc, the by-product of galvanizing iron.

A special paint consisting of a mixture of zinc oxide and lead sulphate is also made in this country according to the BARTLETT process by treating refractory ores containing galena, blende and pyrites in such a manner that the zinc-lead paint results, and at the same time the precious metals present are largely saved.

There has also been proposed an electrolytic process for the manufacture of zinc-white by JACQUES OETTLI[22] during the last year. He subjects zinc plates to the action of electrolysis in a solution of 1 per cent. sodium sulphate at a temperature of approximately 60° C. obtained by means of a current of 10 amperes per square decimeter. Hereby, at the anode zinc sulphate and at the cathode, caustic soda are formed which latter precipitates the former as zinchydroxyde. This is then separated from the solution by filtration, dried and calcined to zincoxyde.

The inventor figures that it will take 74 kw. = 96 electrical horse-power to produce 1 ton of zinc-white by his process. At this figure he is able to compete with the makers of zinc-white who start from spelter, provided that his product has the same good mechanical qualities as that made by burning spelter. Against the United States practice which uses zinc ores as a raw material he can, however, not compete.

CONCLUSION.

As seen from the foregoing, the zinc industry still offers many opportunities to an inventive mind.

The smelting of refractory ores containing both lead and zinc sulphides in such a manner that without preliminary mechanical separation both metals are recovered is still an unsolved problem. The Lungwitz process, if practicable at all, might form a solution.

But even in working straight zinc ores, the results obtained are far from being satisfactory, as with the best practice known, not over 90 per cent. of the zinc in the ores is recovered. Improvements in this respect are to be expected from the use of a material more refractory than clay for the retorts.

The greatest improvements possible lie, however, in the saving of fuel, the consumption of which is still four pounds of coal per pound of spelter produced, working with ores with 50 per cent. zinc and more, and using regenerative furnaces with gas producers. A central gas plant for the production of both heating and power gas would be a decisive step in the right direction, and at the same time it would result in a saving of labor, which is another heavy item in the manufacture of spelter.

Miscellaneous Accessories of Resistance Furnaces.

BY F. A. J. FITZGERALD.

It may be said that in general alternating is preferable to direct current in resistance furnaces, for electrolytic effects are avoided and the voltage across the furnace terminals can be more economically regulated. The variation of resistance with the change in temperature in the resistor necessitates some method of varying the voltage if it is desired to use a constant power throughout the working of the furnace. In dealing with small furnaces it is not necessary in many cases to have means for varying the voltage, for, on account of the small size of the furnace it soon reaches its working temperature and there is not much waste of time in attaining the desired point. To take an extreme case: The resistor of an incandescent lamp rapidly reaches its working temperature, and there is consequently no need for voltage regulation. On the other hand, a 1000-hp. carborundum furnace would take a

[18] Private communication from Dr. R. C. Schuepphaus.
[19] U. S. Patents Nos. 736,611 and 768,054; ELECTROCHEMICAL INDUSTRY, Vol. II., p. 423.
[20] Eng. and Mining Journal, May 16, 1903; ELECTROCHEMICAL INDUSTRY, Vol. I., 1903, pp. 357 and 570.
[21] U. S. Patents Nos. 727,297 and 727,298.
[22] U. S. Patent No. 771,025; ELECTROCHEMICAL INDUSTRY, Vol. II., 1904, p. 465.

long time to attain its working temperature if no means of regulating the voltage were available.

Whenever it is possible, some means of regulating the voltage at the furnace terminals should be provided, for it is a very difficult matter to calculate before hand just what the resistance of the resistor will be under working temperatures. If the voltage at the terminals is invariable, then the furnace must be so constructed that when the temperature desired is reached the resistance becomes constant, and this is by no means easy, unless many experiments have been made.

If possible, the regulation should be effected so that the total available power may be used no matter what the voltage is.

FIG I.—GRANULAR CARBON RHEOSTAT.

This can generally be done within limits where an alternating current is used, but the apparatus used for the purpose is somewhat expensive, so that in experimental work it is often desirable to use merely a rheostat. For this method of regulation a water rheostat may be used, but it is believed that a more satisfactory apparatus is found in the granular carbon rheostat. This consists simply in a trough of fire brick filled with granular carbon and connected in series with the furnace. An ammeter is included in the circuit and a voltmeter connected to the furnace terminals, and from the readings of these instruments the power generated in the furnace may be determined. By increasing or diminishing the amount of carbon in the rheostat its resistance may be varied, so that

FIG. 2.—LONG RHEOSTAT, USED FOR BAKING.

the amount of energy developed per second in the furnace may be regulated as desired. When delicate regulation is required it is not desirable to attempt the removal or addition of carbon; instead, the change in resistance by pressure is made use of. In Fig. 1 a photograph of a granular carbon rheostat is shown. At the left is part of the carbon terminal common to the furnace and the rheostat, while at the right, part of the terminal of the rheostat is shown. The trough is 3 bricks, that is, about 27 inches long, and is partly filled with granular graphitized coke. The three bricks standing on end in the trough are resting on the granular coke and serve in that way for more delicate regulation of the energy developed in the furnace. If the experiments made in the furnace require very delicate regulation of temperature the granular carbon rheostat should be made long, so that the placing of a brick or other weight on the carbon produces but a small change in the resistance of the whole mass. Very delicate regulation may also be obtained by laying pieces of asbestos board, over the rheostat, the asbestos board not touching the granular carbon, but simply resting on the side walls of the trough. By this means the radiation of heat from the rheostat is adjusted, and consequently the resistance regulated with great accuracy.

In Fig. 2 is a view of a long rheostat connected with a furnace, the latter being at the right-hand side of the figure. As a considerable quantity of heat is generated in the rheostat it was found useful in the experiment to use some of this for low temperature baking, hence, the muffle resting on the granular carbon.

Fig. 3 is a view of the furnace of Fig. 2, but taken from the other side. At the right side is the terminal common to the furnace and the rheostat, while at the left side is the cable connected with the other terminal of the furnace. The voltmeter is connected to the common terminal and the furnace terminal, so that the energy generated in the furnace

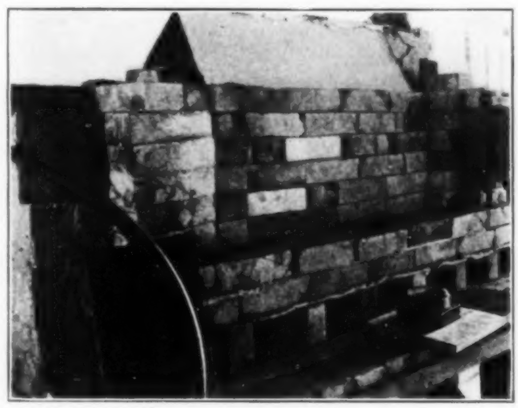


FIG. 3.—RHEOSTAT AND FURNACE

may be determined. The object of arranging the furnace and rheostat with a common terminal is to permit of cutting out the rheostat altogether, thus using the full available power in the furnace.

When a furnace does not require the full available power at any stage of the experiment it is better to omit the common terminal and use the arrangement shown in Fig. 4. This shows the foundation of a rheostat. At the left of the figure is the terminal, while to the right are four graphite blocks which serve to connect the granular carbon of the rheostat with the resistor of the furnace. The smaller a furnace is the more difficult it is to avoid losses by radiation and conduction of heat, hence the importance of constructing the apparatus so that these are reduced to a minimum. The heat conducted away by the terminals is a relatively high percentage of the total, hence the advisability of avoiding structures like a common terminal when possible.

It is obvious that in dealing with large furnaces, a rheostat is not a satisfactory apparatus for regulating the voltage at the furnace terminals on account of the energy absorbed by it.

There are two principal methods of regulating the voltage: (1) An ordinary transformer is used to step-down from the high-voltage line, and then beyond that is a regulator which acts as a variable flux transformer, boosting or lowering the voltage on the line going to the furnace; (2) a transformer with a specially constructed primary which per-

mits of varying the number of turns by a switching device, thus varying the voltage of the secondary.

A good example of the first method is found at the works of the International Acheson Graphite Company, where 750-kw. resistance furnaces are used. The current is supplied at 2200 volts and is brought to a 25-cycle, 800-kw. transformer which delivers a secondary current at 140 volts. The regulator is a 6-pole, 560-kw., 25-cycle apparatus with 140 volts primary, and 60-volt, 9350-ampere secondary. By means of the regulator the voltage of the current delivered to the furnaces can be raised or lowered by 60 volts, thus giving either 3740 amperes at 200 volts, or 9350 amperes at 80 volts, or the corresponding current at any intermediate voltage. The following description of the regulator was kindly furnished to the writer by Mr. W. S. Moody of the General Electric Co., who built the apparatus.

The punchings and windings of the regulator are assembled in a substantial oil-tight, cast-iron case having a semi-

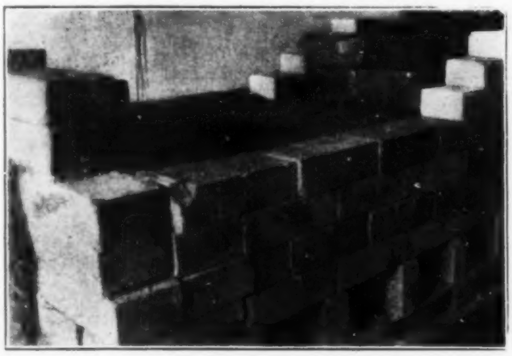


FIG. 4.—ARRANGEMENT OF RHEOSTAT.

spherical cover which is made absolutely tight, so as to prevent dust and dirt getting into the gearing and operating mechanism. Both the stationary and movable cores are built up solid of carefully annealed sheet-iron, provided with a large number of slots for the winding. The windings consist of formed copper bars carefully insulated and assembled in these slots. The ends of the windings are brought out by means of flexible cables to a set of vertical bus-bars brought through the center of the cover. In order to avoid an excessive impedance in the device, and obtain as good a power factor on the system as possible, the windings are sub-divided and the bus-bars of both transformer and regulator are arranged so that the alternate bars are of the same polarity. The sub-division of the regulator windings is obtained by connecting all of the 6 poles of the machine in parrallel, and the extremely low impedance so obtained, together with the exceptionally small magnetizing current for which the regulator is designed, gives a power factor quite as good as is obtained with a transformer having a variable ratio.

The moving core of the regulator contains the primary or shunt winding which is connected to the stationary one by means of flexible cables, and the regulator being 6-pole, the total range of voltage is obtained by a rotation of the core of 60°, that is, 30° each side of the neutral point. The series or secondary winding is placed on the stationary core, and in order to avoid excessive impedance in this winding when the regulator is in the neutral position, the movable core is provided with a short-circuited winding placed at right-angles to the active or shunt winding. This winding being at right-angles to the primary has no effect on the latter, except to concentrate the magnetic flux at the poles, and is only in active operation in the neutral position of the regulator, in which position the winding carries the same current as the secondary. In this position the primary or shunt current does not have to carry current, except the magnetizing current, which is quite a small percentage of the normal full load current. Thus, the loss is not appreciably increased by the addition of this extra winding.

The regulator is shown in Fig. 5, the semi-spherical cover having been removed so as to show the cables connecting the windings of the regulator to the interlaced busbars and the mechanism for rotating the primary core.

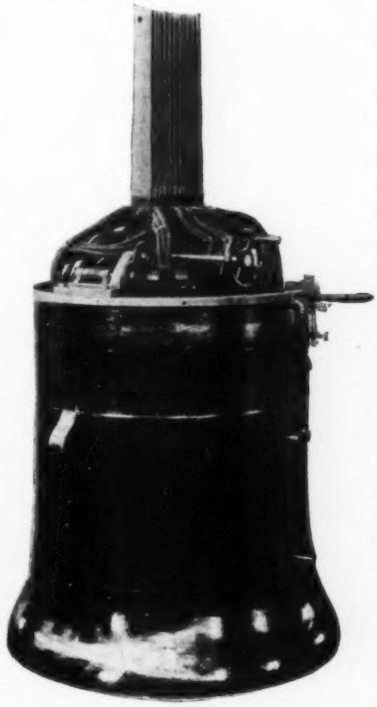


FIG. 5.—REGULATOR.

An example of the latest practice in the second method of regulation is found in a 1600-kw. apparatus built by the Westinghouse Company for the Carborundum Company's furnaces. P. M. Lincoln has kindly furnished photographs and description of the apparatus. This consists of an oil-switch regulator working in connection with the main transformer, and an oil-drum regulator working in connection with an auto transformer. In Fig. 6 there is a general view of the apparatus; at the right is shown the main transformer with the leads going to the oil-switch regulator; at the left the auto transformer connected with the oil-drum regulator. In Fig. 7 the oil-switch regulator is shown with the top removed, discovering the arrangement of cams and levers by which the oil switches are worked. One of the oil

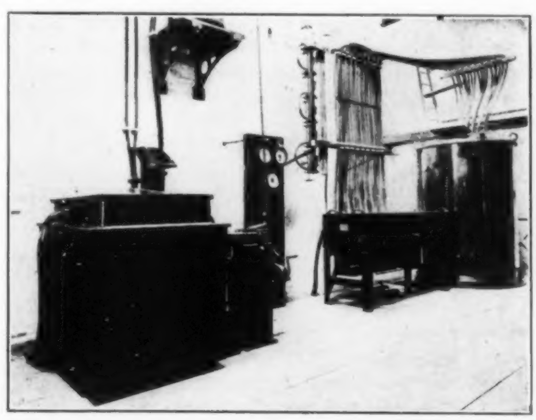


FIG. 6.—GENERAL VIEW OF REGULATION APPARATUS.

switches is shown below with its covering removed. In Fig. 8 the drum regulator is shown removed from its case.

Consider first the main transformer and oil-switch regulator. In Fig. 7 it will be observed that there are 10 switches which we shall suppose numbered from left to right. When the handle is turned, one revolution completes one step in the main transformer. Switch No. 1 is closed at the beginning

of a revolution of the handle, and then switch No. 3, which connects switch No. 1 with the primary of the transformer. Next, switch No. 2 is closed, throwing in a "preventive resistance," which connects the leads going from switch 1 to switch 3 and switch 2 to switch 4, respectively. Then switch 4 is closed, cutting out the first section in the primary of the main transformer. The "preventive resistance" is shown in Fig. 6, mounted on the wall beside the cables coming from the main transformer. The object of using the "preventive resistance" is to avoid the serious sparking that would occur if the circuit was opened at any time during the revolution of the handle. When the handle of the regulator is in the normal position as shown in Figs. 6 and 7, the resistance is cut out so that no section or sections will be short-circuated permanently. At the next revolution of the handle another section of the

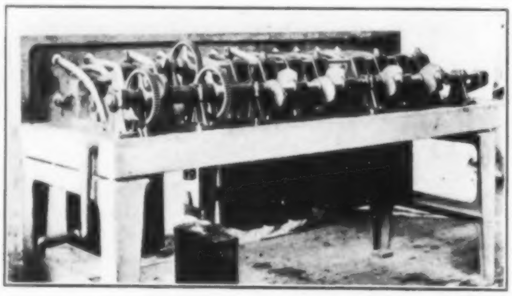


FIG. 7.—OIL SWITCH REGULATOR.

primary of the main transformer is cut out, and so on. Thus the oil-switch regulator cuts out eight sections altogether, switches 1 and 2 simply serving to make the changes.

As the change is voltage produced in the secondary of the main transformer by cutting out one of the sections of the primary would be too great for the carborundum furnaces, the auto transformer and series transformer are used to regulate the voltage between the main steps. The sections of the auto transformer are cut out by means of the oil-drum switch shown in Fig. 8. This also is provided with a preventive resistance and the reversing switch, shown in the figure. The reversing switch is provided with an interlocking device which prevents reversing when the main drum is in any but the off position. There are 15 sections in the auto transformer. In this way, by the combination of big steps in the main transformer and a series of small steps obtained with the auto transformer, a large range of voltage by small increments is realized.

In a modified form of the apparatus built for the International Acheson Graphite Company, the oil-switch regulator is worked in connection with an induction regulator on the primary circuit which permits of a continuous regulation of the voltage between steps.

The question as to which of the two is the better is probably largely a question of cost. It is believed that the second method is somewhat the cheaper of the two, and is said to give a slightly higher efficiency. Against this, however, is the complicated system of switches which obviously introduces a large number of possible causes of trouble.

For electric furnaces using currents of relatively low amperage cables may be employed to convey the current from the generator or transformer to the furnace. In all cases the furnace should be as close as possible to the source of energy, for two reasons: First, because of the saving of copper in conductors. Second, because a better power factor is obtained. For furnaces using currents of high amperage, copper bars are used to bring the current close to the furnace, and cables connect the bars with the furnace terminals. Where heavy alternating currents are carried more than a few feet, it is necessary to interlace the bars carrying the current or the power factor of the system will be very low. In the construction of the supports for the bars, closed magnetic circuits must be carefully avoided. Where there is much dust in the furnace room, as often happens, the bars must be inspected at frequent intervals and dust cleared away in order to avoid troublesome short-circuiting with the formation of serious arcs.

The mention of arcs calls to mind a curious experience which may be worth recording, although the conditions necessary for its repetition are not likely to occur. In a certain factory where electric furnaces were used, the transformer was situated in a small building next the furnace room, and the current supplied to the transformer was brought in at 2200 volts to the switchboard, which was provided with marble panels. For a long time no trouble was experienced with the switchboard, till one occasion, when an arc started between two of the high-voltage switches on the board. The arc was finally extinguished, but the cause of its formation was not discovered. Shortly afterwards the same thing happened again, and this time the marble panel of the switchboard was cracked by the heat of the arc and had to be removed. The writer was asked to make an investigation, with a view of discovering the cause of the trouble. It seemed probable that the arc was started by something on the surface of the marble, which destroyed its insulating properties; accordingly the surface of a piece of the marble was washed off with distilled water. Examination of the wash-water showed that it contained a considerable quantity of calcium chloride, which easily explained the formation of the arc. It happened that an appreciable amount of chlorine was given off by the furnaces, and this, in conjunction with moisture had evidently attacked the marble, forming calcium chloride on the surface of the switchboard.

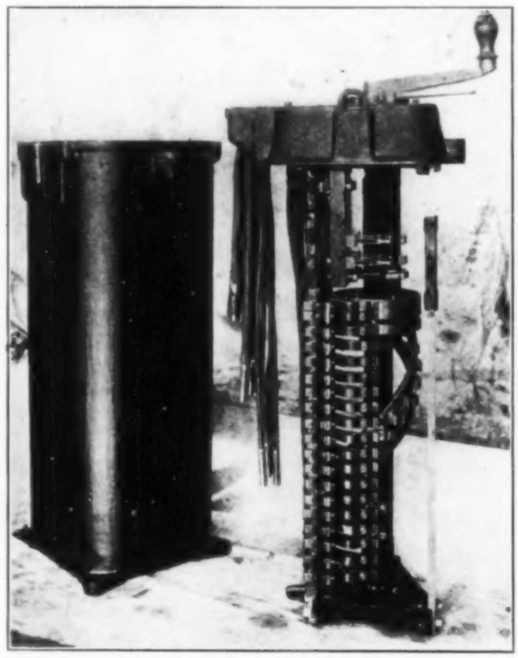


FIG. 8.—DRUM REGULATOR.

One of the most important and troublesome parts of electrical resistance furnaces are the terminals. These are almost invariably built of carbons, with suitable arrangements for connecting the carbons to the cables carrying the current. In special cases, where low temperatures are used, or in small furnaces like those designed for dentists, where the resistor is a platinum wire, metallic terminals may be employed. But in large furnaces using heavy currents, where high tempera-

tures are attained, the only suitable terminal material is carbon. An exception to this may be found in the Gin furnace for the manufacture of steel, which was described by P. McN. Bennie in ELECTROCHEMICAL INDUSTRY, Vol. II., No. 1, January, 1904. Here the terminals consist of large blocks of steel which are cooled by water. However, that is an altogether exceptional case.

In America carbons suitable for making the terminals of resistance furnaces are almost invariably made of petroleum coke. The writer only knows of one furnace process where terminals made of other forms of carbon are used, for in most cases objections would be found to carbons containing considerable quantities of ash, and of the cheaper forms of carbon petroleum coke is freer from ash than any other. Indeed, carefully selected petroleum coke, taken from the middle of the retorts so as to avoid all contamination from "scale," is as pure a form of carbon as can be obtained. In Europe, however, terminal carbons made of anthracite coal are used, and in this connection the following extract from a translation by E. Ornstein of a lecture by Julius Zellner will be of interest:

"The recent crisis in the calcium carbide industry has forced the carbide manufacturers to institute economies. Their greatest expense is in the purchase of electrodes, consequently they have done their best to obtain these as cheaply as possible, and have been successful, for in three years the selling price of this product has diminished by 50 per cent.

"The factories producing electrodes have been forced, on account of the cost, to abandon the use of retort carbon and to investigate the treatment of anthracite coal, a much less expensive raw material. The anthracite coal electrodes turned out to-day by all well-equipped factories have a longer life than the retort carbon electrodes made three years ago. While in the early days of the manufacture of calcium carbide, the consumption of electrodes amounted to 10 or 15 kilograms per 100 kilograms of carbide, at present it reaches only to 6 to 10 kilograms at the most, some manufacturers asserting that they consume only 3 per cent.

"The impurities in anthracite coal, at least 3 to 5 per cent of ash, prevent its use in the manufacture of alumina (aluminium?). The electrodes used in this industry are made of petroleum coke, which can be obtained with an ash content of 0.1 per cent.

"So far the employment of charcoal for electrodes has not met with success, for the articles made of this material, which is cheap and low in ash content, have a much greater electrical resistance than those made of other varieties of carbon. Hence, they use too much of the current energy, which precludes their employment"[1]

For much furnace work the presence of the impurities found in anthracite coal would be unobjectionable, but how these carbons would compare with the articles made from petroleum coke when used as terminals, the writer is unable to say, having had no experience with them. It seems probable that one objection to their use might be that they would not allow the use of as high a current density. The writer has made a determination of the real density of a specimen of an anthracite coal electrode and found it to be 1.78, while the real density of a good specimen of a petroleum coke electrode, as made in this country, is about 1.98. In general the electrical conductivity of carbon is greater, the greater the real density, which would indicate that petroleum coke electrodes have the higher electrical conductivity. According to the quotation given above it would appear that the carbon consumption was much less in the case of anthracite coal than in that of retort carbon; but it seems probable that a part of this improvement is due to better design of the furnaces in which the carbons are used.

Another form of carbon for terminals is that produced by the International Acheson Graphite Co. The method of manufacturing these articles is well known; they are made of petroleum coke in the ordinary way, except that a samall amount of some carbide-forming substance is added and are then heated to the highest attainable temperature in an electric furnace. The advantages of these carbons are: Low electrical resistivity, greater resistance to combustion than amorphous carbon articles, ease of machining. The disadvantages are: Relatively high cost, high heat conductivity, up to the present large-sized articles are not manufactured. The last objection refers to length especially, as it is understood that 4 feet is the maximum length attainable, while amorphous carbons can be obtained as long as 6 feet.

In using carbons for resistance furnace terminals the current density that may be allowed varies somewhat according to circumstances; but in general we may use with amorphous carbons a density of 30 to 40 amperes per square inch, and with graphitized articles a density of 80 to 100 amperes per square inch.

The heat conductivity of graphite electrodes is so great that if the temperature of the ends in the furnace is high, the outer end of the carbon will also become so hot that it may be necessary to use some device for cooling, such as a water jacket. In working with small electric furnaces and relatively large graphite terminals, the loss of heat by conduction becomes serious. This heating effect is by no means so marked in the case of amorphous carbon terminals.

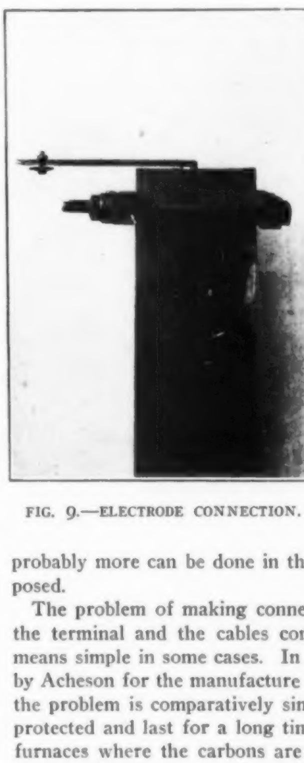


FIG. 9.—ELECTRODE CONNECTION.

The ease with which graphite electrodes can be machined is often of great advantage, for they may be put in a lathe and treated like a metal; drilled, turned, threaded, etc. For a description of this feature the reader is referred to C. L. Collins' article in ELECTROCHEMICAL INDUSTRY, Vol. II., No. 7, July, 1904. The machining of amorphous carbon electrodes is by no means so simple, though probably more can be done in that way than is generally supposed.

The problem of making connection between the carbons of the terminal and the cables conveying the current is by no means simple in some cases. In furnaces of the type designed by Acheson for the manufacture of carborundum and graphite the problem is comparatively simple, for the carbons are well protected and last for a long time without renewal. In those furnaces where the carbons are exposed to destructive influences and wear away more or less rapidly, the difficulties met with are great.

A very simple form of connection is shown in Fig. 9. The carbons are each 4 inches square, and between them is clamped a ¼-inch copper plate bent at right angles. The plate is drilled with a hole through which a bolt passes, thus permitting connection to be made with the cable carrying the current. All parts of the clamp should not be made of iron, for in that case a closed magnetic circuit would be formed, which is objectionable, as already pointed out. If the part of the copper plate between the carbons is about 12 inches long, the terminal will have a capacity of at least 1000 amperes, with amorphous carbon and about 2500 amperes with graphite In the latter case, however, if the end of the terminal in the furnace was very hot, it would be necessary to

[1] Translation from Revue d'Electricité; October 8, 1904; page 49.

use long electrodes in order to avoid serious heating of the outer end. In Fig. 10 an end view of a terminal built on this principle is shown in place in a furnace.

Another method of making connections that may be used with graphite electrodes, is to drill out the latter and thread the hole, so that a bolt may be screwed into it. Or the round end of the electrode may be threaded and a metal cap screwed on. The objection to both these arrangements is that the coefficient of expansion of metals suitable for caps or screws is much greater than that of carbon, so that in the case of the bolt there is a possibility of breaking the electrode, and in the case of the cap the contact becomes loose. If the terminal connections are so fitted that they can be sufficiently cooled, these objections are not so serious.

In order to make the best possible contact between the carbon and the metal it is advisable to use graphite between the two. For example, in putting together the terminal shown in Fig. 6, there should be layers of graphite between the copper plate and the carbons. The graphite used for this purpose should be pure, and very soft, so that it will readily compress and adjust itself to all irregularities on the surfaces of the plate or electrodes. A good form of graphite for this purpose is that obtained by the decomposition of silicon carbide at high temperatures.

Where this cannot be obtained a pure grade of Ceylon graphite may be used; but this should first be treated in the following manner: The powdered graphite is put into an iron pot or kettle, such, for example, as the pots used in melting solder, moistened thoroughly with concentrated nitric acid, heated gently at first and then strongly, so as to drive off the last traces of acid. Treated in this way, the graphite swells up greatly and a beautiful soft product is obtained, which is perfectly satisfactory for the object in view.

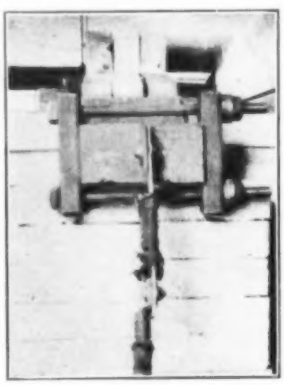


FIG. 10.—END VIEW OF TERMINAL CONNECTION.

In using this material for making connection between the copper plate and the carbon electrodes, as shown in Fig. 6, it should be sprinkled on evenly to a thickness of at least ¼ inch, for when the clamp is tightened the graphite will be compressed to a very thin sheet. A joint between copper and amorphous carbon made in this way will easily carry 10 amperes without serious heating. In applying the nitric acid treatment described above it is important to use Ceylon graphite, because all forms of graphite have not the property of swelling or intumescing when treated in this way.

When a terminal is built up in the manner described, using even amorphous carbon electrodes, the heat conducted from the interior of the furnace may be so great that the outer ends of the carbons are raised to a red heat. It then becomes necessary to protect the carbon from the air, and some modification of the terminal becomes necessary. As the methods used depend upon various circumstances, they will not be discussed here.

Before leaving the subject of the terminal connections, attention should be directed to a very ingenious furnace terminal, patented by Henry Noel Potter. ([2]) This is designed to overcome the difficulties due to unequal expansion of carbon and metals. Fig. 11 is a section of the terminal. *A* is the carbon of the terminal, *C* is a block of copper or brass, which is held tightly against *A* by the bolts *D*, *D'* passing through *C* and the washer *B*. The principle of the terminal connection is the proportioning of the parts so that the expansion of *A* and *C* by heat just compensate for the expansion of the bolts *D* and *D'*. The copper *C* having a greater coefficient of expansion than the bolts will compensate for the expansion of the latter, thus preserving a constant contact pressure between *A* and *C*.

In using amorphous carbon electrodes for terminals in electric furnaces it is of the first importance that they should be thoroughly baked. Carbon electrodes that are not thoroughly baked have a higher electrical resistivity than well-baked carbons, and are likely to crack when exposed to high temperatures. The fitness of carbon electrodes for furnace work may be tested by determining their electrical resistivity; but such a determination is not easy to make, and requires somewhat expensive apparatus. On the other hand the determination of the density of carbon is comparatively simple, and the desired information can be obtained in that way.

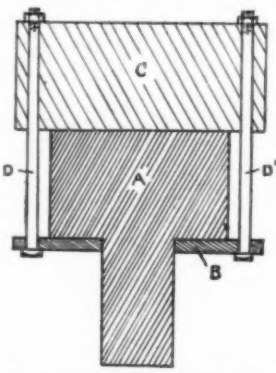


FIG. 11.—COMPENSATED TERMINAL CONNECTION.

A carbon electrode has two densities which may be determined: *Real Density;* that is, the ratio of the weight of the carbon to its *real* volume, and *Apparent Density;* that is, the ratio of the weight of the carbon to its *apparent* volume, which is the sum of the volumes of the carbon and the pores. The higher the temperature at which carbon has been baked, the higher the density, the increase in density increasing continuously till the carbon is converted into graphite. It follows, therefore, that from the real density of the carbon we may form an estimate as to how thoroughly the carbon has been baked. It has been shown elsewhere that the electrical conductivity of carbon increases permanently by heating to high temperatures, hence the importance of baking at high temperatures. But in considering the current-carrying capacity of an electrode the apparent density must also be kept in mind. It is easy to conceive that an electrode might be so porous that although it had been thoroughly baked it would not bear a heavy current density, on account of its porosity.[3]

Notes on the Metallurgy of Sulphur Compounds in the Zinc Retort.

By WOOLSEY MCA. JOHNSON.

The action of sulphur in a zinc retort is not only interesting from a scientific standpoint, but has a direct practical bearing on the treating of zinc ores in the reduction furnace. A great deal has been written on this subject, and while I have not given the question the rigid experimenting I did the reduction of zinc oxide, nevertheless some account of the experiments I made may prove of interest to zinc metallurgists.

The first point that naturally confronts one is how the sulphur occurs in the roasted ores. How much of the sulphur is bound to the zinc, and how much is bound to the other elements present How much is present as sulphate, and how much is present as sulphide For a fuller discussion of this the reader is referred to Ingall's "Metallurgy of Zinc," chapters on roasting of zinc ores.

However, a few general principles may be laid down here,

[2] U. S. Patent No. 770,312; September 20, 1904.

[3] For a method of testing carbon electrodes, see Transactions of the American Electrochemical Society, Vol. II., page 43. ELECTROCHEMICAL INDUSTRY, Vol. I., page 68.)

although they may be well known to many. To insure a better understanding of some special points of this paper, we will give a short discussion of these general principles.

It may be assumed that in any kind of a properly operated roasting furnace, the percentage of sulphur as zinc sulphate is less than 0.1 per cent. Mr. W. M. Sanders made in our laboratory at Harpe, Kan., several determinations of the decomposition temperature of zinc sulphate. He used for his cell one of the graphite testers we have used in our laboratory.* He found as a mean of several determinations at atmospheric pressure, the temperature of dissociation to be 739 degrees C. This has been confirmed in a private communication by an independent investigator.

As the temperature of the zinc roasting furnace is always 200° C. higher, and sometimes 300° C. higher, than 739° C., it is apparent that the dissociation pressure is always high enough to drive off any SO_3SO_2 and O, provided the ore is rabbled enough in the current of gas. Any amount of sulphate of zinc is thus due to faulty roasting on the part of the men operating the roasting furnace or in the case of a mechanical roasting furnace, due to weak mechanical engineering. Naturally, there is no sulphate of iron present, for the decomposition of iron sulphate is some 100° below that of zinc sulphate.

Lead sulphate is undoubtedly formed, for its decomposition point is high, and with ores containing a large percentage of iron the catalytic effect of the ferric oxide provides for a large percentage of SO_3 in the roast gases.

In many zinc works in the Iola gas belt, reduction is allowed, for sulphur bound to lead, on the supposition that *all* the lead is present as sulphate. This, it is quite certain, is an unwarranted assumption. It was my intention to investigate this thoroughly by chemical analysis, but there were many other things to be done of more importance, and therefore I had no time to give this question the investigation it really deserved. I am convinced, however, that it is extremely important, and that a properly operated hand roasting furnace can control this factor. This will furnish one reason why in certain instances, ores roasted on the hand-roasting furnaces will give much better results in the reduction furnace as regards yield of metal than ores roasted on the machine calciners.

With regard to lime, there is no doubt that it will take up at least 95 per cent of sulphur as sulphate. Chemical analysis, small scale and large scale experimenting by me, as well as by many others before me, have proven this beyond a doubt. Prof. Carl Petraeus, formerly connected with the Lanyon Zinc Company insisted in justice to the men on the roasting kilns who were paid a premium for roasting ores low in sulphur that this fact be taken into account. Consequently, the men are paid on a basis of "Faulty sulphur:" that is, total sulphur less sulphur combined as sulphate of lime. This was a wise procedure, for it is obvious that nobody can do the impossible.

It is also true that below a thousand degrees C. magnesia acts somewhat as does lime. Perhaps, at a high heat, say above 1100° C., it dissociates. At all events, this sulfation undoubtedly occurs to 80 to 90 per cent in the temperatures usually used in roasting zinc ores, namely, 900° to 1075° C.

There remains always from .05 per cent to .50 per cent sulphur, combined with zinc, iron, lead or other similar metals as sulphides. This is due to imperfect roasting, because of lack of proper rabbling, too low a heat, or lack of oxygen in the roasting gases. The question to which of these metals it is combined, is, of course, a most difficult question to decide. That it is already combined with the zinc is impossible to prove.

Assuming, however, that it is combined with the zinc as zinc sulphide, we will discuss the behavior of zinc sulphide in the reduction and distillation process in the retort.

*See Transactions of American Electrochemical Society, April, 1904.

Experiments done by Percy fifty years ago show that zinc sulphide is completely decomposed by *iron* and zinc at a high temperature. When I started to study the reactions used in the metallurgy of zinc I repeated almost all of the experiments given in Percy's metallurgy, sometimes with considerable amplification. We found that iron decomposes zinc sulphide at a temperature of 1167° C. This action is very slow at this temperature, but if the iron is in a molten state, the reaction proceeds with great vigor. We found that 5 per cent of the theoretical quantity of iron would decompose 98.4 per cent of the sulphide of zinc at a temperature slightly above the melting point of cast iron, *i. e.*, 1250° C.

We also found that carbon starts to decompose sulphide of zinc at a temperature of 1200° C., but with the reaction above that temperature, is much slower than is the reaction with iron. A temperature of 1300° C., however, will decompose sulphide of zinc with time.

As there is always a large amount of carbon present in the retort, and in some cases a large amount of iron present and the temperature is usually as high as 1200° to 1300° C., there can be no doubt but that a considerable amount of the zinc sulphide present in the roasted ore is decomposed with the formation of metallic zinc in the eighteen hours of treatment to which the mixture of roasted ore and reducing material is subjected.

The reaction of iron and zinc sulphide is naturally an aid to the condensation of the metal, for it makes a metal vapor undiluted with any neutral gas. The reaction of carbon on zinc sulphide is, however, not so disadvantageous to the condensation of metal, for the reason that in the condenser the reaction reverses to some extent. Thus, we have sulphide of zinc and carbon formed in the condenser. Naturally this is very bad, depositing a kind of a fine soot on the particles of molten zinc and preventing their coalescing. It is quite apparent to one who has watched the zinc furnace when the ore has been improperly roasted and much sulphide of zinc is present in the roasted ore that this reaction occurs at about 11 o'clock in the night when the retorts are subjected to an increasing heat. The flame which shows up at the mouth of the condenser, is of a peculiar greenish color, quite different from the white flame caused by too fast a rate of reduction and imperfect condensation. The formation of iron sulphide as a result of the first reaction is not a good thing, in one way, for iron sulphide is extremely corrosive, and will dissolve fire clay with the formation I believe of a complex sulpho-silicate.

The action of sulphates in the processes is even more complicated than the action of sulphides in the processes. At seven to eight o'clock, at a lower temperature than is the case with the sulphates, these sulphates begin to break up and form also a peculiar white flame of somewhat similar, yet different character than the white flame caused by sulphides. Both these flames are termed by the furnace men "foxy flames." The first "foxy" flame can be prevented, to some extent, by having a large amount of active carbon as reducing agent. There is undoubtedly reduction of these sulphates, but the reaction and "between-reactions" are too complicated and too uncertain to put down on paper. Whether there is reduction from zinc sulphate to the metal with the formation of carbon disulphide and carbon monoxide, or even carbon monosulphide can be neither confirmed or denied. At all events, the facts are known that any amount, say half a per cent of sulphur or sulphates, is bad in causing an imperfect condensation in the retort by a process similar to that described above in the reduction of zinc sulphide by carbon. It is simply a fact that almost all the oxygen and some of the sulphur goes off into volatile compounds. These compounds in the condenser where the atmosphere is at a lower temperature and of not so strongly a reducing nature as in the retort, reoxidize some of the zinc to zinc oxide, and also resulphurize some of the zinc to zinc sulphide. The end result is the same in all cases. The condensation of metal is

not as good, more blue powder is formed, and, in certain cases, the losses increased.

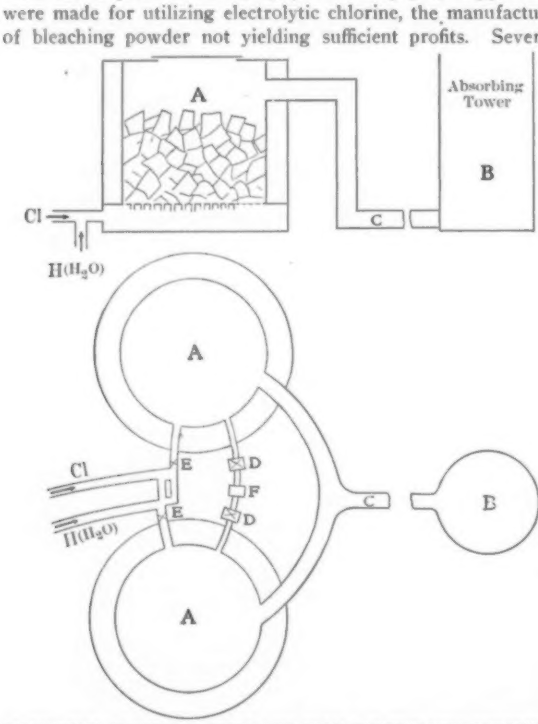
However, a proper mix and proper care to the operation in the distillation furnace will quite prevent this. There is one thing certain, that no one can make the definite statement that "1 per cent of sulphur holds back 2 per cent of zinc." This is the opinion of every smelterman who has given the subject attention. All will agree that sulphur in roasted ores is a bad thing, but how much of the losses amounting to 8 to 25 per cent of the zinc present in the ore is due to sulphur, and how much is due to such as poor coal, improperly mixed ore, poor retorts, careless setting of the condensers, too rapid firing, "poor loom" (which makes bad leaks at the butt of the condenser) or any of the hundred and one factors which contribute to make a low recovery, is a question that passes the capability of human mind. It is hard to diagnose the real causes. There is in the zinc business altogether too much of the fallacy called by logicians "post hoc ergo propter hoc."

One thing is, however, clear to my mind, that properly roasted ore will give much better results in the distillation furnace as regards metal and consumption of retorts than improperly roasted ore, even though sulphur in the first case be as high as one per cent, and the second case as low as 0.2 per cent. The roasting furnaces should be operated, not to produce roasted ore, low in sulphur, but roasted ore that will give the best results in the distillation furnaces. The object of a zinc works is not to show good roasting reports, low in sulphur, but to make zinc.

Utilization of Electrolytic Chlorine.

By Oskar Nagel, Ph. D.

In the September issue, 1904, of this paper, suggestions were made for utilizing electrolytic chlorine, the manufacture of bleaching powder not yielding sufficient profits. Several



PRODUCTION OF HYDROCHLORIC ACID FROM ELECTROLYTIC CHLORINE.

products were mentioned that could be made by means of chlorine. However, the most important one, for the manufacture of which the largest quantity of chlorine could be used, was omitted, that is, muriatic acid.

Several experiments were made in Germany some time ago for making muriatic acid by combining hydrogen with chlorine with satisfactory results, but this was at the time when the manufacture of muriactic acid from electrolytic chlorine was absurd, the manufacture of bleaching powder being the more profitable of the two processes. However, since that time conditions have changed and especially in this country the making of muriatic acid is now more profitable than the manufacture of bleaching powder.

The manufacture of muriatic acid from electrolytic chlorine would yield very large profits at the present market conditions, as a much higher price is paid for the chlorine contained in muriatic acid, compared to the chlorine in bleaching powder. Assuming the price for bleaching powder at \$1.25, for muriatic acid 22 B with \$1.75, we easily see that about 1½ cents more are obtained per pound of chlorine if it is sold as muriatic acid, compared with the chlorine in bleaching powder. If we take the salt used in electrolysis as a basis for this estimate, we find that by making muriatic acid from electrolytic chlorine we are getting about ¾ of a cent more per pound of salt as with bleaching powder.

The reaction $H + Cl = HCl$. is taking place without any difficulty and explosions, if the mixture of these gases is lead through glowing coke. It is to be recommended to have two such vessels filled with coke on hand for using same alternately, as thereby we are enabled to blow the coke hot in one vessel after it is cooled off, and to use meanwhile the other vessel. From these converters, which are filled with coke, the muriatic acid goes by means of a pipe-line, in which it is sufficiently cooled, to the condensing towers, where it is absorbed by water.

Great care must be taken in this process for obtaining a muriatic acid free from chlorine and therefore the following reaction, which works easily and satisfactorily and is always yielding acid free from chlorine, is to be preferred:

$$Cl_2 + 3H_2O + 2C = CO_2 + CO + 2HCl + 2H_2.$$

This reaction is taking place quantitatively at 1,000°C, which temperature is easily obtained by blowing air through coke, analogous to the water gas process. After one minute blowing, chlorine can be made for about seven to eight minutes.

The apparatus to be used for this reaction is practically the same as for the other process.

The gases escaping after the condensation of the muriatic acid can be used for fuel or power purposes.

Muriatic acid made from electrolytic chlorine is far superior to and could command a much higher price than the ordinary acid, the former being free from iron and arsenic.

On the Contents of Carbonate in Electrolytic KOH Solutions and in Solid Caustic Potash.

By F. Winteler, Ph. D.

Since solid caustic potash, as well as 50 per cent solutions are sold according to the content of free KOH, while nothing is paid for the content of carbonate, it is in the interest of the manufacturer to place a product on the market which contains as little carbonate as possible.

The analysis of a whole series of caustic potash products of European electroytic works showed that the content of carbonate often assumes considerable proportions, as will be seen from table 1, the first row representing the number of 19 samples of so-called 100 per cent caustic potash and the next two rows the contents of KOH and K_2CO_3 in per cents by weight respectively.

Table 1.

No.	1	2	3	4	5	6	7	8
Per cent KOH.	77.0	78.1	76.6	75.2	76.3	73.3	77.1	74.7
Per cent K_2CO_3.	11.1	16.6	14.6	16.2	17.2	11.0	12.0	18.4

9	10	11	12	13	14	15	16	17	18	19
76.4	79.5	76.3	80.9	79.7	77.6	78.1	77.4	81.8	77.3	80.8
14.8	6.8	14.8	11.2	11.2	7.8	5.6	4.7	2.4	4.4	3.0

It will be seen that the content of carbonate differed greatly in the various samples and was often more than 20 per cent of the amount of KOH contained in the same.

The caustic potash solution produced by an electrolytic process, using a diaphragm cell or the gravity process ("Glocken" process), is free from carbonate, although dilute and containing potassium chloride as in impurity. The presence of carbonate in the commercial product would, therefore, indicate that the carbonate was introduced during the process of evaporation and casting.

If the vessels which contain the solution before evaporation are not covered, the solution absorbs carbon dioxide from the air. The same occurs in the reservoirs, after coming from the vacuum evaporators. Here the carbonization will go on to a greater extent on account of the higher concentration of the lye (50° B) and of the higher temperature. It is, therefore, in this case of still greater importance to keep the reservoirs closed air-tight. The barrels in which the highly concentrated caustic is heated should be provided with a head-piece as in distilling apparatus. The analyses of Table I show that in some European works not sufficient attention is paid to these requirements.

In order to find the maximum quantity of carbon dioxide which a 50° B. caustic potash lye, such as comes from the vacuum evaporators, is able to absorb, I have made the following experiments.

Fifty degrees B. caustic potash was thoroughly shaken, while hot, with solid potassium carbonate for some time, and then set aside for twelve hours and analyzed.

The composition was at a temperature of 22° C. KOH 70.68 per cent by volume, and K_2CO_3 5.53 per cent by volume.

The same lye contained, after five days, at a temperature of 20° C. KOH 71.46 per cent by volume, and K_2CO_3 4.50 per cent by volume.

Another sample of lye of 51° B. contained, after having been shaken hot for some time with K_2CO_3, after forty-eight hours at a temperature of 20°C.: KOH 76.07 per cent by volume, and K_2CO_3 3.73 per cent by volume. After another forty-eight hours KOH 76.3 per cent by volume, K_2CO_3 3.7 per cent by volume.

These figures represent the maximum amount which a concentrated aqueous solution of potassium hydroxide is able to absorb. If cast caustic potash contains a higher percentage of carbonate, this must have been absorbed during the casting process. Exact experiments on the question how the fused caustic can become saturated with carbonate were found very difficult, since temperature and concentration are of very great influence.

However, from the observations of the author, it follows that when caustic potash, strongly saturated with carbonate, is left standing for some time in fused condition, the greatest part of the carbonate settles out at the bottom. If the upper clear portion is then put into iron drums, a pretty satisfactory commercial product of 3 to 5 per cent of carbonate by weight is obtained. The red sediment on the bottom of the pots, which is colored by iron oxide, and consists mainly of carbonate, is then dissolved so as to form a 10 per cent solution of KOH. This solution is then treated with lime in the same way as in the Leblanc process. The caustic potash solution of about 10 per cent, thus obtained, is then passed into the vacuum evaporators, and after having been concentrated, goes to the melting pots.

Corrosion of Metals by Electrolysis.—At the spring meeting, 1903, of the American Electrochemical Society, A. A. Knudson spoke at length on his investigations on the corrosion of water pipes and gas pipes due to stray currents passing from the rails of trolley systems into the earth. (ELECTROCHEMICAL INDUSTRY, Vol. I., page 318.) Mr. Knudson has recently made a study of similar damage in Bayonne, N. J. His results are given in *Eng. News*, November 17.

Investigation of the Properties of Zinc Coatings.

BY PROF. CHARLES F. BURGESS.

The importance of zinc as an agent for protecting iron and other metals from corrosion is strikingly demonstrated by the fact that over one-half of the zinc produced is used for this purpose. That the efficiency of the zinc coating varies greatly with the purity of the metal, its thickness, continuity and method of application is well known, though the degree to which these various factors affect the efficiency seems to have received but little attention, if one may judge by published data.

Since certain new methods of applying zinc coatings have, to a certain extent, come into competition with the older "galvanizing" processes, the question as to how the protective power of such coatings compares with the older ones becomes of interest and importance.

It was the purpose of an investigation undertaken in the Applied Electrochemistry Laboratory of the University of Wisconsin to determine, if possible, the relative value of zinc deposited by the electrolytic or "cold" processes and the metal as applied by the "hot" or dipping methods. Such determination proved to be somewhat difficult and unsatisfactory, since it involved the devising of methods for determining the properties of zinc coatings. At best, such methods can be only approximations.

While the literature relating to the electrolytic deposition of zinc is extensive, there are but few references to the durability of zinc so deposited as compared with zinc coatings obtained by dipping in molten zinc. The impression is prevalent that electrolytic zinc is much more protective and durable than the other form of zinc. Cowper-Coles makes such assertion in a series of articles on the "Protective Action of Zinc" (*Industries and Iron*, October, 1898), from which the following is an abstract:

"The zinc applied by the hot method usually contains lead, tin and iron. It has been found that iron above .13 per cent makes the zinc too brittle to bend. Lead, up to 1 per cent, is harmless, but above 1.5 per cent, will not dissolve, and the excess collects and forms weak spots. On the other hand, zinc applied by the electric process is very pure, and it is found to resist the corroding action of a solution of copper sulphate very much better than hot galvanized iron. A specimen of hot galvanized iron, having 1.42 ounces per square foot, withstood three one-minute immersions, while a similar piece of electrogalvanized iron having 1.26 ounces per square foot withstood five immersions.

"Results of sulphate of copper tests made on samples of charcoal iron, coated with zinc by different processes:

Process Used to Coat the the Iron.	Grains per Square Foot.	Oz. per Square Foot.	Number of One Minute Dips Samples Stood Without Showing Metallic Copper.
Hot galvanizing	648.5	1.48	3
Acid bath, $ZnSO_4$......	446.5	1.02	4
Neutral bath, $ZnSO_4$...	552.64	1.26	5

"From this it is seen that steel coated by the electric process will have as long a life as hot galvanized steel, and with much less zinc."

Properties Influencing Value of Zinc Coatings.—The properties upon which the value of a zinc coating depends include the following:

The durability of the zinc and the protection of the underlying metal against corroding influences.

Adherence to the zinc coating.

Toughness and malleability of the coating.

Continuity and density and uniformity in thickness.

Resistance of the zinc to abrasion.

Methods of Testing.

In the determination of these properties for various zinc coatings, recourse could not be had to standard methods of measurement, since no such methods, suitable for the purpose, have been proposed. The methods which were adopted in this investigation are naturally open to criticism, but certain deductions may be derived from them which give approximations to the properties studied.

Durability of Zinc Against Corrosion.—The corrosion of zinc may be defined as a chemical reaction between the metal and the liquid in contact with it. This corrosive agent may be the moisture in the atmosphere, the solutions which impregnate the earth, sea water, or corrosive liquids, such as acids dissolved in water, which may be in contact with it, and the corrosive action may, in the various cases, be considered as differing principally in the rapidity of the chemical action which takes place.

The accurate determination of the life of a zinc coating under practical conditions can be made only after a lapse of months, and for laboratory investigation a more active corroding agent than that afforded by the atmosphere is necessary. The only rapid test which appears to have been applied to zinc-coated iron is the well-known copper sulphate test, which consists in immersing the sample in a saturated copper sulphate solution for periods of one minute or less. The number of such dips which a sample will stand before showing a deposition of copper on the exposed iron, or until all the zinc has been removed, has been taken as an indication of the life of the coating when subjected to corrosion under practical conditions. While this test may be a satisfactory one for roughtly determining the relative thickness of zinc coatings on iron wire or other galvanized ware, it is far from satisfactory as showing the relative values of different qualities of zinc. An objection to the copper sulphate test is that there is no sharp reaction which indicates just when a portion of the underlying iron has been exposed, or the time when the entire coating has been removed.

The question may naturally arise as to whether a rapid corroding test can be applied as a means for determining the durability of a zinc coating when exposed to the much slower corroding influences of the atmosphere, sea water and similar agencies. It is desirable that the rapid method shall approach as nearly as possible to the practical conditions in all respects other than rapidity of corrosion, and copper sulphate seems to be one of the least satisfactory materials which could be chosen as fulfilling this requirement. It acts not only as a strong acid in dissolving the zinc, but the dissolving zinc causes, by galvanic action, a precipitation of copper upon any exposed iron or upon the zinc itself. This deposited copper in turn sets up, with the zinc, a very active galvanic couple, such as is rarely produced under practical conditions, and which causes an abnormally rapid dissolution of the zinc. Copper sulphate is very rarely the corroding influence to which these surfaces will be exposed under practical conditions.

Many tests were made, using the copper-sulphate method, but the only value it seems to have is in being an approximate method for determining the thickness, but not the durability, of a zinc coating. The various kinds of zinc, whether electrolytic or not, or whether attached to iron or separated from it, seem to be corroded by the copper sulphate solution at equal rates. No measurements were made with this solution which will confirm the data previously referred to, as given by Cowper-Coles. The data obtained from tests made with copper sulphate will be given under the discussion of the results of tests.

The action of dilute acids approaches more nearly the practical conditions of corrosion, being similar to the action of impure water upon zinc, and in a certain degree comparable to the action of the various gases and moisture in the atmosphere. Possibly a better test would be one in which the galvanizing is subjected to various gases, such as chlorine, sulphur fumes, and other similar materials, in the presence of moisture, but these tests are naturally very slow, requiring weeks, and sometimes months, to obtain any indications of corrosion. Consequently they are hardly practical for the purposes in hand.

Many trials were made for the purpose of determining the most satisfactory acid to use in the tests of zinc coatings and the most suitable strength of such acid for the production of uniform and comparable results. The data from these tests are not included here, but from them was adopted a solution of 2/3 normal (= 3.2 per cent) sulphuric acid, to be used at room temperatures as the corroding agent to be employed.

The reason for adopting this strength of solution was that the corrosive action was sufficiently rapid to enable a measurement to be made within a reasonable time, not greatly exceeding one hour. It is probable that the more dilute the solution is, the more nearly will it approach practical conditions, but where economy of time is necessary, the stronger solutions must be used. For most practical purposes, where greater rapidity is required, it seems desirable to employ stronger solutions than were used in the tests here described.

The rate at which zinc will dissolve from an iron object depends to a certain extent upon the amount of iron surface which is exposed, simultaneously with the zinc, to the acid. If the iron be completely covered by zinc so that none of it makes contact with the solution, the zinc itself will dissolve very slowly, as shown by the fact that a stick of solid zinc not in electric contact with any other metal, when dipped into sulphuric acid, corrodes at a very slow rate. It would be inaccurate, therefore, to compare a sheet of iron which has been electrolytically galvanized over its surface and edges with a similar sized sample cut from a sheet of galvanized iron. In the latter case the iron is exposed all around its edges, while in the former case it is not, and a corrosion test applied to such sample would show erroneously the advantage to be in favor of the electrogalvanized coating. For better comparison, therefore, in all of the measurements, the samples to be tested were cut so as to expose an edge of the iron all around.

The method employed for conducting the tests was as follows: Thin-sheet galvanized iron was used in most cases. From this, test samples were cut having dimensions 2 inches x 5 inches, and, therefore, a surface area of 20 square inches. Each sample, previous to the test, was scrubbed with vienna lime to remove any dirt or grease which might interfere with the action of the corroding solution. The sample was carefully weighed and then immersed in the standard sulphuric acid solution and left for certain definite periods, after which it was removed, rinsed, brushed, dipped in alcohol, dried, and again weighed. The loss of weight thus obtained gave an indication of the rapidity of corrosion. These dips were repeated until all the zinc had been removed, or until it had been removed sufficiently to determine its relative resistance to corrosion.

The point at which all the zinc is removed can be quite sharply determined by noting the cessation of the rapid evolution of hydrogen, and also by the very small loss of weight which occurs after the zinc has been completely dissolved. The rate at which the iron itself dissolves in the acid is a very small percentage of the rate at which the zinc in contact with iron dissolves, and the iron can be left in the solution for a considerable time after all the zinc has been removed without losing appreciably in weight. By the weight of the sample before and after the removal of the zinc the amount of zinc which was originally on the surface is readily determined. This can be done with a very small percentage of error, inasmuch as little or none of the iron dissolves while zinc is present, and the process can be stopped as soon as the zinc has been completely removed.

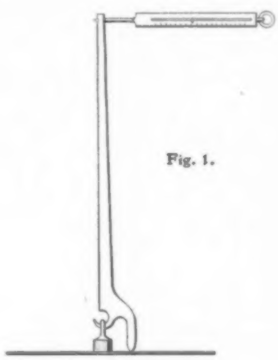
The length of time that a given weight of zinc will last, as shown by such tests, is assumed to indicate, approximately, the durability of the zinc against corrosion in general. Different

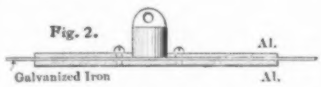
kinds of zinc and different qualities of coatings show a remarkable variation in durability, as will be pointed out later.

ADHERENCE.

There seems to have been no work previously done in determining the degree of adherence of zinc coatings, and, inasmuch as such determination seemed desirable, a method of testing this property was devised along the following lines:

The method consists in soldering to the zinc surface, by means of a low-melting solder, a copper plug one-half inch in diameter. By noting on a spring balance the pull necessary to separate this plug from the iron, a measurement of the adherence of the zinc to the iron is made. The zinc adheres, by means of the solder, to the brass plug with a greater strength than to the iron. By this apparatus, which is illustrated in Fig. 1, a fair degree of uniformity of measurement was obtained and the relative adherence of different kinds of coatings derived.





FIGS. 1 AND 2.—ARRANGEMENT OF TEST AND METHOD OF SOLDERING.

An error may possibly come into this test, from the fact that the sample must be heated to a point sufficiently high to cause the solder to adhere. This heating undoubtedly decreases the adherence of an electrolytic zinc coating to the iron, while it does not decrease in like degree the adherence of the coating which has been applied by the hot process. It may also be suggested that a very porous coating will allow the solder to penetrate through the zinc and adhere directly to the iron, thus giving an erroneous value. This was found, however, not to be the case.

There is some tendency for the solder to run out from the edges of the brass plug and thus adhere both to the brass and the surrounding zinc, increasing the force necessary to pull the plug away. This error was eliminated by cutting away such surrounding solder. To avoid that operation, the method of soldering shown in the accompanying sketch (Fig. 2) was adopted. The galvanized iron was held between two aluminium plates, one of which had an opening into which the brass plug fitted. By applying the solder in this opening, and then applying the brass plug, the adherence was effected without the solder flowing on the zinc surface not covered by the plug.

An example of the failure of galvanized coatings is seen on galvanized pipes leading from heating furnaces. The alternate heating and cooling of these pipes frequently causes the zinc to become detached in large scales. To determine whether electrolytic zinc behaves in a similar manner, samples of various kinds of galvanizing were heated and cooled alternately and the effects thus produced observed.

The toughness and strength of the coatings were tested by passing various samples between iron rollers. In some cases the coatings were so brittle as to be cracked off in scales by this treatment, and in other cases the zinc seemed to be pressed into the iron, and to preserve a perfectly continuous coating. By bending such samples at a sharp angle after having been compressed by the rollers, the coatings could in most cases be peeled off. Such coatings were then examined for brittleness, ductility and porosity.

The continuity of the coatings was determined by examination of samples removed in the manner previously mentioned, and also by the use of a microscope.

The method employed for testing the resistance to abrasion consisted in placing samples of galvanizing in a porcelain-lined tumbling barrel, together with quartz sand. By revolving this at slow rate for a number of days, weight determination showed the amount of zinc which was removed per unit area of surface.

Another test consisted in determining the degree to which galvanized iron could be bent before developing cracks in the zinc. This was done by placing a strip of the iron in a device especially constructed for the purpose, by means of which the amount of deflection that is required to produce cracks in the coating can be measured, the cracks being detected by means of a microscope.

RESULTS OF TESTS

Resistance to Corrosion.—To show the relative values of different zinc coatings as based upon their power to resist the action of corroding influences, twenty samples were prepared and the tests conducted in the manner previously described. Immersion was made for five-minute periods, until the total time of immersion had reached one hour; ten-minute periods for the second hour, and twenty and thirty-minute periods later. The loss of zinc after each dip was determined to a fraction of a milligram. From such measurement the rate of corrosion of zinc at different times was determined, and the results are plotted in accompanying curves, the time in minutes being measured on the horizontal axis, and the rate of corrosion in milligrams per square inch of surface per minute on the vertical axis.

Four determinations were made upon hot galvanizing and sixteen determinations on various thicknesses of electrolytic deposits, and upon deposits obtained from neutral and slightly acidified solutions. The electrolyte from which the deposits were obtained consisted of an ordinary plating solution of zinc sulphate and aluminium sulphate. In the practical operation of such a solution it becomes desirable to add occasionally a small amount of free sulphuric acid to prevent the formation of a precipitate of basic zinc salt, and the tests were designed to show the effect upon the durability of the zinc caused by the presence of this free acid in the plating solution.

It was found that the amount of zinc applied by the hot process is about 25 to 28 grams (one ounce) per square foot, and the electrolytic coatings used ranged from 8 to 34 grams per square foot.

The tests were all run in duplicate; that is, two samples, as nearly alike as possible, were cut from each plate. Where the weights of zinc are alike on the two samples of similarly galvanized iron, the curves of corrosion are quite similar. In some cases, where samples were cut from the same sheet, there is considerable difference in the amounts of zinc, which is due to unequal distribution of current on the cathodes, although care was taken to make the distribution as uniform as possible.

The samples of hot-galvanized iron, which are designated 1, 2, 3, 4, respectively, were obtained from two different dealers, and represented two different grades. One grade had much larger crystals or spangles on the surface than had the other. It is seen from the curves for these samples that the corrosion begins immediately upon immersion, and the rate increases rapidly to a comparatively high value, and then falls off as the iron becomes more exposed.

These tests, toegther with many others not here recorded, show that the hot process zinc was in all cases completely removed in less than one hour's time. The various samples were found to be fairly uniform as to the weight of zinc per unit area, and the rates of corrosion are similarly uniform. These curves may, therefore, be taken as fairly representative of galvanized sheet iron as ordinarily obtained on the market.

It should be noted that the usefulness of the zinc coating must be judged, not by the length of time it takes for the zinc to be completely dissolved, but rather by the length of time for the curve to become maximum. There are two explanations for the fact that the rate of corrosion increases to a maximum,

rather than remaining at a uniform rate. On the supposition that the corrosion is due to small galvanic couples set up between the zinc and small impurities imbedded in it or between the zinc and exposed portions of the iron, as the dissolving of the metal proceeds, an increasing number of particles of impurity come to the surface and furnish more galvanic couples and consequently increased corrosion. Another explanation is that the corrosion produces a roughness of the surface, and thereby an increased area of surface in actual contact with the acid. This increase cannot go on indefinitely, since after a certain amount of the zinc has been dissolved, its surface decreases, and it is after this point is reached that the iron becomes rapidly exposed.

Table I. gives the methods of preparing and data for the test samples.

TABLE I.

No. of Samples.	Wt. of Zn. per Sq. Ft.	Amp. per Sq. Ft.	Time of Deposition, Min.	Solution.
1	25 g.	Hot galvanized.	..	.....
2	25.6 "		..	......
3	27.98 "		..	......
4	27.39 "		..	......
5	8.48 "	14.4	30	Neutral
6	7.87 "	"	30	"
7	9.9 "	"	30	Acid
8	8.1 "	"	30	"
9	17.1 "	"	60	Neutral
10	14.7 "	"	60	"
11	16.7 "	"	60	Acid
12	13.8 "	"	60	"
13	28.38 "	"	90	Neutral
14	23.69 "	"	90	"
15	25.64 "	"	90	Acid
16	21.7 "	"	90	"
17	33.9 "	"	120	Neutral
18	29. "	"	120	"
19	34.14 "	"	120	Acid
20	30.16 "	"	120	"

The curves for corrosion of 5, 6, 7, 8 are somewhat similar to those for the hot galvanizing, though showing a somewhat lower durability, and demonstrating that 8 or 9 grams of electrolytic zinc is not sufficient to be the equivalent of the hot galvanizing coat. The subsequent curves show in a striking manner the advantage of increasing the thickness.

A one-hour coating is seen in curves 9, 10, 11, 12 to be more durable than the hot-process coating, even with much less zinc. Curves 13, 14, 15, 16 show that the one and one-half hour coating corrodes vary slowly for the first two hours, and then increases its rate, though it corrodes at no time with the degree of rapidity of the first four samples. The two-hour coating, as shown in curves 17, 18, 19, 20, corrodes almost imperceptibly for a period of five or six hours, and its protective action is by far the best of all the coatings tested.

A summary of the results of these tests is given in Table II., in which column 1 gives the number of the samples; column 2, the weight in grams of the zinc on the samples; column 3 gives the weight in grams per square foot; column 4, time in minutes which it took for the zinc to be completely removed; column 5 gives the protective action of the zinc, expressed as "minutes per gram per square inch;" column 6, the weight of zinc which should be deposited with a current efficiency of 100 per cent, and, assuming that the current density was exactly 14.4 amperes per square foot, uniformly distributed; column 7 gives results of tests on similar samples in a copper sulphate solution.

From column 2 it is seen that it takes one and one-half hours' run at the current density of 14.4 amperes per square foot to produce a coating which has the same thickness as the ordinary galvanizing. It will be noted, however, in column 4 that the electrolytic coating will stand about 500 minutes' immersion, while the galvanized varies between 50 and 60 minutes. With 8 or 9 grams of zinc per square foot deposited electrolytically, the time of corrosion is 30 to 90 minutes, showing that with even that small amount of zinc it is possible to get a protective action equivalent to that of three times as much zinc obtained by the hot process. From column 5 may be obtained the best idea of the relative durability of various kinds of zinc coatings expressed in time per gram per square inch. These values were obtained by dividing the length of time it took for the coating to be removed by the amount of zinc on the unit area.

An explanation, which is suggested for the remarkably favorable showing of electrolytic zinc over zinc deposited by the hot dip, is that the hot galvanized has a certain amount of impurity in the form of iron, lead and other materials, and is therefore really an alloy. Such an alloy will dissolve very readily in an acid solution, owing to local action, which is set up between the particles of the different metals. This results in a more rapid corrosion than where a single metal is immersed in a corroding solution, as is the case with the more pure electrolytic zinc. It is well known that if absolutely pure zinc be immersed in a pure acid, little or no corrosion will take place unless contact is made with platinum, iron or some other electronegative element. If electrolytic zinc, deposited upon iron, so completely covers the iron that none of the underlying metal can come in contact with the solution, then the galvanizing will act as a pure piece of zinc. If it is porous, however, there are galvanic couples set up wherever the acid penetrates these pores, resulting in a rapid corrosion of the zinc. This is probably the condition when the zinc coating has insufficient thickness. By increasing the thickness of the coating, these pores are gradually bridged over until there is little or no chance for the corroding agent to get through to the iron, and thus the rate of corrosion of the zinc is greatly reduced.

It will be seen from curves 17 nd 18 that the corrosion of the standard sulphuric acid solution upon zinc deposited to a

TABLE II.

Sample.	Wt. of Zn. on 20 Sq. In.	Wt. of Zn. per Sq. Ft.	Time in Minutes.	Time per Gram. Sq. In.	Wt. as Calculated from Current.	No. dips in $CnSO_4$ Before all Zn was Removed.
1	3.4846	25.09	50	.72	....	12
2	3.6950	26.60	60	.86	....	12
3	3 8865	27.98	55	.71	....	12
4	3.8054	27.40	50	.66	....	12
5	1.1786	8.49	35	1.5	1.21	5
6	1.0931	7.87	30	1.35	1.21	5
7	1.3776	9.92	90	3.25	1.21	..
8	1.1251	8.10	45	2.	1.21	..
9	2.3759	17.11	240	5.05	2.42	8
10	2.0747	14.94	200	4.85	2.42	7
11	2.3214	16.71	240	5.2	2.42	..
12	1.9204	13.82	185	4.85	2.42	..
13	9.9438	28.39	570	7.25	3.63	9
14	3.2900	23.69	450	6.85	3.63	8
15	3.5624	25.65	430	6.05	3.63	..
16	3.0139	21.70	220	3.65	3.63	..
17	4.7091	33.90	870	9.25	4.84	12
18	4.0275	28.99	890	11.05	4.84	11
19	4.7424	34.14	740	7.8	4.84	..
20	4.1900	30.17	570	6.8	4.84	..

thickness of 30 grams per square foot was less than one gram in six hours. After that amount had been removed, however, the iron became exposed to such an extent as to cause a more rapid corrosion, and the rate of dissolving increased at a much more rapid rate during the succeeding time.

By a comparison of columns 2 and 6 in Table II., it may be noted that in some cases the actual amount of zinc deposited was very nearly equal to the amount calculated from the current and the electrochemical equivalent. In other cases, the amount was somewhat less. These variations are due to slight errors in the measurement of the current, but more largely to

the unequal current density on different parts of the plate, which had received the deposit. Samples 4 and 20 were cut from cathodes 10 inches x 10 inches, which had been plated by surrounding them with a wooden frame to prevent an excessive current flowing to the edges of the plate, and by this means it was attempted to get the current density as uniform

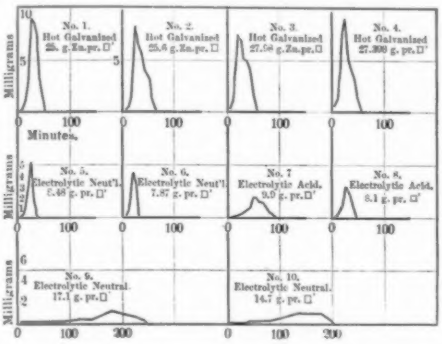


FIG. 3.—RESULTS OF TESTS 1 TO 10.

as possible. The odd numbered samples were taken from near the edge of the plate, and the even numbered ones, near the middle. It will be seen that the samples nearest the edge of the plate show a greater amount of zinc than do the even numbered ones. An idea of the distribution of the current can be obtained by comparing these values.

Tests of Zinc Coating with the Copper Sulphate Solution.—To determine the showing which the copper sulphate test gives for the different kinds of coatings, samples similar to 1 to 4 and 5 to 12 were dipped for one-minute periods in saturated copper sulphate solution. After each immersion the plates were thoroughly scrubbed, dried and weighed to determine the amount of zinc lost. The plotting of this data gives curves of an entirely different form from those obtained with the dilute acid solution, showing that the character of the corrosion is materially different. In Table II., column 7, is given the length of time each sample stood this test. It will be noted that in all of the samples the durability of the coating against copper sulphate was approximately proportional to the amount of zinc in the coating. These tests show only a slight difference between different kinds of zinc coatings of equal thickness, the advantage being slightly in favor of the hot-process product.

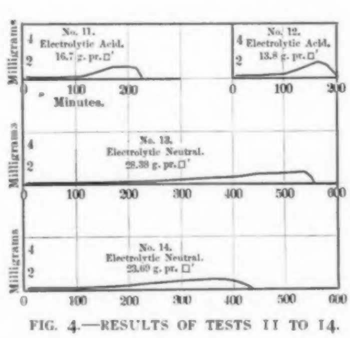


FIG. 4.—RESULTS OF TESTS 11 TO 14.

It was found also that it makes little or no difference in using this copper sulphate method of testing, whether the zinc is in contact with iron or not. That is, a piece of solid sheet zinc corrodes as rapidly from its surface as though it were in contact with iron. It is believed, therefore, that the sulphuric acid test is one which approaches much more nearly practical conditions, because the ordinary corroding influences to which galvanizing is subjected are such that zinc in contact with iron corrodes more rapidly than does sheet zinc. In fact, it has been demonstrated in practice that solid sheet zinc will last indefinitely, while zinc in contact with iron has a limited life. The only useful purpose that the copper sulphate dip will serve is as a rough method for determining the amount of zinc which a layer contains, the number of dips being proportional to the thickness.

Samples of corrugated sheet iron which had been galvanized by both the hot and the cold processes were tested for corrosion by the acid solution, and it was found that they were approximately equal in durability, though the electrolytic product had much less zinc than the other. A noticeable defect of the former was that the zinc was not evenly distributed, this being due to the fact that the convex portions of the service received a greater current density than the concave portions, which were further from the anode.

Pieces of the corrugated galvanized iron were subjected to the corroding action of sulphuric acid fumes, such as are liberated directly over a storage battery, and also to chlorine liberated by the electrolysis of sodium chloride. The action of these gases was continued for six weeks. With the sulphuric acid fumes, this length of time was not sufficient to produce any marked results, but with the chlorine, corrosion of the underlying metal took place. This test demonstrated that the electrolytic zinc was fully as durable as the thicker hot-process coating.

Adherence of Zinc Coating.—The tests for the degree of adherence of zinc coatings, as carried out in the manner previously described, show that it takes almost twice as great a force to separate the electrolytic zinc from the iron as it does the hot galvanized. The average of a considerable number of determinations gives the following values:

Zinc deposited from a zinc sulphate plating solution, 482 pounds per square inch.

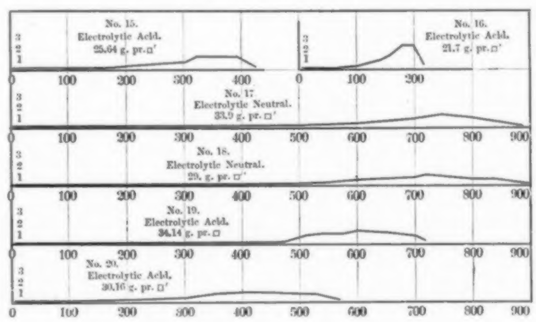


FIG. 5.—RESULTS OF TESTS 15 TO 20.

Galvanized iron obtained from local dealers, 280 pounds per square inch.

Tests were also made on zinc which had been deposited from a cyanide plating solution, and gave values around 230 pounds per square inch.

It was found that a considerable variation in different tests on a single piece of material existed, showing that both the hot and cold galvanizing were not uniform in their degree of adherence over the entire surface. The variation was found to be greater with the hot galvanized than with the cold.

While these measurements of adherence show decidedly to the advantage of the electrolytic process, they were not sufficiently extensive to warrant a definite statement as to relation. The adherence undoubtedly depends upon the care with which the surface has been prepared previous to receiving the zinc. This is especially true as regards the electrolytic deposit.

The Effect of Heating and Cooling.—One of the disadvantages of the galvanized iron is that by rapid heating and cooling, the coating becomes non-adherent and separates from the iron in large flakes. A number of tests were made to determine which of the two methods of galvanizing has the advantage in this respect, but the length of time required to make these tests has prevented this question from being definitely determined. It was observed, however, that electrolytic zinc shows a decided tendency to blister on heating, and that this tendency is not manifested in the hot galvanizing. This blistering seems to be due in part to the unequal expansion of the

two metals, and the greater toughness of the electrolytic zinc causes it to buckle away from the surface, whereas a more brittle hot galvanizing does not show this tendency. Another cause of blistering is the expansion of enclosed portion of solution. The conclusion may be drawn that where the material is to be heated the electrolytic zinc is inferior to the older form.

Toughness and Malleability of the Coatings.—It is desirable that the zinc coating have a certain degree of toughness and malleability, especially where galvanized sheet iron is to be bent into various desired shapes. If these properties are lacking, it tends to crack or crumble when subjected to bending stresses. Tests were made by passing samples of galvanized sheets between iron rollers in such a way as to reduce the total thickness by about .01 inches. The effect of this treatment upon the hot galvanized sheet was, in certain cases, to cause it to flake away from the iron, while the electrolytic sample showed no such tendency. By bending the samples back and forth, after having passed them through the rollers, it was found possible to separate the zinc coating from the iron in strips of considerable size. Electrolytic zinc was found to be perfectly uniform and tough, and with a high degree of strength, while the hot galvanizing was very brittle.

The results of tests to determine how much bending a sample will stand before developing cracks in the surface, show that the amount depends to a great degree on the thickness of the coatings, the thin coatings naturally being decidedly superior to the thicker in this respect. No decided difference between hot and cold-process coatings of equal thickness could be detected.

Continuity, Density, and Uniformity of Coating.—The porosity of the coating is a factor determining to a large extent the rapidity of corrosion. Various kinds of galvanizing were examined by a microscope to determine this property, and it was found that the hot galvanizing is very porous, being perforated by minute holes, which are quite apparent by stripping off some of the coating and holding it to the light. It was noted that the lines of contact between the crystals are marked by a large number of perforations.

Electrolytic zinc also has been found to be quite porous when in layers of less than 10 grams per square foot, while coatings of twice that thickness show no perforations.

As is well known, a hot galvanized coating is not uniform in thickness. The crystalline nature shows the manner in which it varies, and there is also a tendency for the zinc to be thicker around the edges, especially in that portion which leaves the bath last, than in other parts of an article. The uniformity, however, is greater with hot galvanizing than with the electrolytic processes, and where irregularly shaped objects are plated, the lack of uniformity on the electrolytic produce is very decided. This is due to a non-uniform distribution of current over the surface of the objects plated, a higher current density existing around the edges than at the center, and at parts of the object nearest the anode.

Resistance to Abrasion.—To determine whether there is any relative advantage as regards the resistance to wear, a number of samples of similar size were placed in a tumbling-barrel with quartz sand. The amount of zinc removed after being subjected to the wearing action for several days showed that there is very little difference in the mechanical wearing quality of hot and electrolytic galvanizing.

CONCLUSIONS.

The principal fact brought out in these investigations is that with the corroding agent adopted, electrolytic zinc has resistant properties far superior to zinc applied in the molten condition. It may, with some justice, be inferred that a like relationship will hold when natural corroding influences prevail. To prove without question the exact value of this test will require observations covering some years.

The results of measurements enable us to specify what dimensions an electro-coating shall have to compete favorably with the other coating. It is found that for equal durability the electro zinc should be present in an amount equal to about 12 grams per square foot, requiring about 10 ampere-hours for its deposition. To attain the advantage of great durability the electrolytic coat should be as thick as the hot galvanized deposit, or about 28 grams per square foot. This can be produced by 28 ampere-hours or 14 amperes per square foot for two hours.

It is seen that to obtain the best quality of coating the disadvantages of the electrical method are brought out, the principal one of which is the great length of time required to apply the deposit. This can be remedied only by the use of high current densities, and with solutions at present available, it seems impracticable to run the density beyond 18 or 20 amperes per square foot on account of the liberation of hydrogen and undesirable physical quality of the deposit produced. In the tests made, 14.4 amperes per square foot was taken as best representing practical conditions where a cold, unagitated solution is used. With this current density the metal may be deposited with a current efficiency of nearly 100 per cent.

A serious limitation upon the electrolytic process as at present applied is that after the coating has reached a certain thickness there is a tendency for it to become rough and crystalline, and this tendency makes it extremely difficult to apply a coating having more zinc than 30 grams per square foot.

The conclusions regarding electrolytic zinc are based upon data obtained by the use of the one zinc plating solution described. This particular solution was chosen as being extensively used in practice, and tests made on a great many different compositions of bath showed this one to yield the best quality of deposit.

Even with this solution the quality of deposit was found to be sensitive to slight changes within the tank, a somewhat surprising observation being that with a decrease in the amount of anode surface, the appearance and durability of the deposits were improved. The amount and also the distribution of the anode surface have therefore a direct bearing on the quality of deposit.

A great difficulty lies in securing an even distribution of current over the object being plated, as demonstrated on corrugated sheet iron and other irregularly shaped articles. This causes, also, greater thickness and roughness around the edges.

The tests of durability show that the best results are attained with solutions operated as nearly neutral as possible, and that the addition of free acid, which seems desirable for keeping a clear solution, not only decreases the current efficiency, but also materially reduces the efficiency of the zinc as a protection.

There seems, therefore, abundant opportunity for improvement in zinc plating solutions, even though present methods are giving good results industrially. Such improvements may come through the discovery of new compositions for the bath which will enable higher current densities to be used, thicker deposits to be obtained, and greater stability and uniformity of operation acquired. Circulation has been suggested as an improvement, and it is to be expected that the advantages which efficient agitation gives in copper depositions may also be realized with zinc plating vats.

The adherence of zinc coatings to iron is frequently ascribed to an alloying which is supposed to take place. The tests for adherence indicate that no such alloying occurs, either with hot or electrolytic galvanizing, since the tenacity with which the coatings adhere is far less than would be expected if alloying existed.

Laboratory of Applied Electrochemistry,
University of Wisconsin.

CANADA.—In a recent consular report we note that the first lead pipe ever made in Canada from Canadian lead is now being produced at Trail by the Canadian Smelting Works; any dimensions required are made up to 4 inches in diameter. It will be remembered that the Betts electrolytic refining process is in use in Trail.

Notes on Electrochemistry and Electrometallurgy in Great Britain.

(From Our Special Correspondent.)

PRESIDENTIAL ADDRESSES AND ELECTROCHEMISTRY.

Mr. Robert Kaye Gray's presidential address to the Institution of Electrical Engineers last year was notable for its comprehensive review of the entire electrical situation. In this, of course, the latest developments in electrochemistry and in electrometallurgy were touched upon. Mr. Alexander Siemens' presidential address, delivered on the 10th of November, was wholly of a different order, being in the mature partlyof a reviewof the economic conditions, other than fiscal, which contribute to the success or failure of engineering works, partly of a recitation of views on the metric system diametrically opposed to Mr. Gray's, and a criticism of the latest British patent laws.

Mr. Fletcher Moulton, whose combination of legal talent and technical skill is alike the wonder and envy of many, delivered an interesting and able address before the Society of Chemical Industry. His address was an able resumé of the present outlook of the world's chemical industries. Of the lack of success which has attended many of the attempts to electrolytically produce organic compounds, this "was most disappointing but intelligible, multitudes of reactions were possible, and not easily stopped at the right moment." Mr. Moulton was very hopeful concerning the outlook of electrometallurgy, which is already giving us sodium, phosphorus, calcium carbide, carborundum and graphite. One point may be cited as bearing on the effect of accident upon scientific research. It was mentioned that in one of the greatest of the triumphs of modern chemistry—the synthetic preparation of indigo—an unexpected increase in the yield had been observed after the accidental breakage of a mercury thermometer, which added mercuric sulphate to the reagents present.

At the Civil and Mechancal Engineers' Society, the president, Mr. C. T. A. Hanssen, chose for the subject of his address, "The Effect of Patent Law on Modern Civilization." Throughout the speaker pleaded for the better remuneration and protection of the inventor. Vast benefits have been derived from the work of inventors, who themeselves had shared to a small degree only in the resultant prosperity. A longer duration was suggested in order to repay the heavy expenditure usually incurred in developing and pushing a new enventia. It was also suggested that patents, instead of being issued at a uniform rate of taxation, should be taxed according to the income derived from the monopoly. This would result in a considerable revenue from successful patents, while the charges for undeveloped inventions might be considerably lowered. Most electrochemists would probably welcome changes of this novel and interesting order.

Sir William Abney, at the Society of Arts, dealt mainly with the relations existing between the State and Science. The National Physical Laboratory should be transferred from the Royal Society to a special Government department as is the case in the United States, Germany and France.

Lastly, I must allude to the startling address which Mr. Swinburne delivered to the students of the Institution of Electrical Engineers, entitled "Some Difficulties in Getting On." As reprinted in the *Electrician*, those not present may read five columns of brilliant epigrams and genial chaff of those who devote themselves to scientific research at the expense of developing their business instincts. From the charter of the Institution of Civil Engineers down to the general pursuit of knowledge very few subjects went untouched. For instance, "Science, for which no use has been found, or which is not applied, is called 'Pure Science,' whereas it is really the raw material, and should be called 'Raw' or 'Crude Science' * * * No knowledge is worth obtaining for it own, or any other sake, unless it is, or will probably be, useful to man. * * * A genius does not work for a given employer; he works for the world at large, and the world does not pay him." As a broad rule, Mr. Swinburne would measure the worth of the average man by his earnings. All this is very iconoclastic. Professor Perry and others will have much to say for the other side. It is well, however, that one of Mr. Swinburne's scientific attainments, and practical knowledge should urge the development of the business instinct, although much of what has been said is more suggestive, say, of George Bernard Shaw than, say, of Karl Pearson.

HYPOCHLORITES AND SEWAGE PURIFICATION.

The past summer has seen a revival at Guilford of the attempts to sterilize sewage effluents with solutions of hypochlorite of soda electrolytically prepared. This application of the hypochlorites is by no means new. Hermite's plant at Worthing, Woolf's installation at Riker's Island, Danbury, Conn., and at Brewsters, Putnam County, N. Y., were the earliest attempts. The Hermite experiments at Worthing attracted considerable attention. The electrochemical efficiency was, however, low; much trouble was experienced with the insulation of the anodes, while the solutions produced were, according to Roscoe, very unstable. Indeed, a depreciation of 25 per cent of the strength of the available chlorine produced occurred in twenty-four hours. Of Woolf's American demonstrations that at Riker's Island consisted in deodorizing about thirty acres of putrefying garbage. The plant at Danbury, as the writer remembers it, merely provided for the admixture of a certain amount of "Electrozone" (as Woolf called his solution) to crude sewage. At Brewsters, electrozone was added to the water flowing in a small brook, which ultimately made its way into the Croton Reservoir. Here, an almost complete sterilization was effected. As to how long these plants remained in operation, or as to the amount of success which attended the Havana plant, the writer is unable to say. In 1895 a company was formed in England to work the Woolf patents, and at first a temporary and then a more permanent plant was erected at Maidenhead. A long series of experiments showed that the hypochlorite solutions prepared would sterilize effluents from any ordinary filter or even an effluent from a precipitation tank. It was also found that to oxidize the organic matter present would require too great a consumption of free chlorine. A gallon of electrozone containing 4 grammes of free chlorine to the litre would sterilize 1000 gallons of tank effluent, or 1600 gallons of filtered effluent. Reckoning electricity at 4 cents a unit, and salt at $6.00 a ton, 1000 gallons of tank effluent could have been sterilized for 0.7 cents. Such a figure leaves out of calculation royalty, supervision, and repair and renewal of electrodes.

The experiments of the past summer at Guilford were carried out by the Oxychloride Co. The writer believes that an Atkins electrolyzer was used, in which a revolving drum of lead acts on the cathode, while the anode consists of a semi-circular trough of carbon. No figures have yet been published of the electrochemical efficiency obtained, cost of salt used, working strength, or stability of the electrolyte. Dr. Rideal, who has carried out a long series of experiments at Guilford, reports that 3¼ galons of oxychloride are needed to sterilize a filtered effluent. It is a pity that no figures of the cost of production are given.

The new company will have to fight against the apathy of British municipalities and water supply authorities. At present only chemical standards of purity of a sewage effluent are recognized. When bacteriological standards are laid down, it will speedily be apparent that treatment with ozone or treatment with hypochlorite solutions are the only alternatives which are reasonably cheap.

THE FARADAY SOCIETY.

The Society's meeting on the 23rd instant was fairly well attended, several members who are not regular attendants

being attracted by their having read the advanced proof of Professor Kahlenberg's attack on the dissociation theories of Arrhenius and van't Hoff. The enjoyment of the evening was greatly marred by Professor Kahlenberg's absence. Your correspondent, remembering vividly a celebrated heresy hunt at a northern Synod, in which there was war to the knife between two theological schools, and remembering also that the debating of opposing scientists is second only to that of theologians in order of rancor, went, expectant of hard hitting. In this he was not disappointed. A lengthy abstract of the paper having been read, Dr. Lowry was the first to speak. Speaking with extreme rapidity, never at a loss for a word or phrase, the speaker expressed his sense of a temptation to differ from Professor Kahlenberg at nearly every point, the paper being chiefly founded on a misconception of the theory as held at the present day. Point after point was raised and dismissed in a few words, the influence of viscosity being urged as an important factor in such investigations. Communications were then read from Mr. Wetham, Professor Abegg, Dr. Rudorf, Dr. Sand, and Dr. Desch. The general trend of their opinion was that, while the Arrhenius theory was not all-explaining, yet it was so successful that a mere citation of difficulties is not sufficient to occasion its rejection. What was really needed was an alternative theory leaving fewer unexplained difficulties. The debate was continued by Dr. Borns and Mr. Spiers, and closed by the vote of thanks moved by Mr. W. R. Cooper, who was in the chair. (A rather full abstract will be found on another page of this issue under the title Faraday Society Meeting.—Ed.)

Metallurgical Papers Read in November.

While neither electrochemical nor electrometallurgical in its scope, mention must be made of the paper read by Messrs. A. E. Seaton and A. Jude at the Institution of Mechanical Engineers on November 18th, entitled, "Impact Tests on the Wrought Steel of Commerce." The authors point out that tests as to the elastic limit and tensile strength, while in themselves valuable, do not afford all the indication which is desirable in the case of structures to rapidly repeated loads of one kind more or less suddenly applied, as bolts, studs, rails, etc., or for structures subject to alternating loads, such as the fixed and moving parts of machinery. Whereas tensile testing machines make practically no distinction between the steel that is utterly unfit and that which is eminently fit for the parts of a machine subject to shock or vibratory stresses, the drop-testing machines does most certainly and without fail make the discrimination. Further, wherever the drop-testing machine shows a steel to be good, the tensile testing machine corroborates it.

The subject of Mr. E. A. Weinberg's paper, read before the Institution of Mining and Metallurgy on November 17th, is probably more familiar to American engineers than to their English confreres who listened to the paper. Its title was "The Blake-Morscher Electro-Static Separator," and included, with its description and a narration of the practical working results obtained in Colorado on account of the Wagner mica plate static machine, used by the author in his own experiments.

The Electro-Thermic Manufacture of Steel and Smelting of Iron Ore.

Up to the date of mailing this letter, very little attention has been given in London to the report of Dr. Eugene Haanel and Mr. F. W. Harbord (otherwise described in Canadian official documents as "The Commission") on this subject. *The Electrician* has published a leading article on the subject of a recitative rather than a critical order. Mr. Harbord is, however, to read a paper on the subject before the Faraday Society, when probably more attention will be given to it. (The report was abstracted and discussed at great length in our December issue.—Ed.)

Market Quotations.

So far as chemicals are concerned there has been practically no change during the month of November. Apart from copper sulphate, which has now risen to £23 per ton, prices on November 30 are almost identical with those quoted on November 2. Bleaching powder is fetching £5.5.0 per ton, caustic soda (white 70 per cent) £10.15.0 per ton, and lead peroxide is £27.10.0.

Fine Para rubber is still rising 5s. 2d. to 5s. 5½d. per pound. The metals generally are advancing in price. Platinum is now quoted at £4.1.6 per ounce—an advance of 1s. 6d. during the month. Aluminium is stationary, ingots fetching £130 per ton, wire and sheet £168 per ton. Electrolytic copper bars have risen from £66 to £70.10.0 per ton ,electrolytic sheet and rod fetching, respectively, £87 and £81 per ton. H. C. wire has risen three farthings per pound to 9¼d. Cleveland pig iron has risen 3s. 0d., now reaching 47s. 8d. Block tin is now being sold at £137 to £138 per ton. Zince sheets have risen £2.10.0 to £29.7.6. Brass sheets and tubes have risen slightly in sympathy with the rises in copper, tin and zinc.

Faraday Society Meeting.

The ninth ordinary meeting of the Faraday Society was held in London, November 23, 1904, at the Institution of Electrical Engineers, Mr. W. R. Cooper being in the chair.

Electrolytic Dissociation Theory.

The first paper presented was by Professor L. Kahlenberg of the University of Wisconsin. In the absence of the author it was read in abstract by the secretary.

Dr. Kahlenberg starts with the remarks that in creating the theory of electrolytic dissociation, the phenomena of actual electrolysis have played a minor part, and that the hypothesis of Clausius, which displaced the old Grotthus theory and brought conceptions of electrolysis into harmony with thermodynamic requirements, is by many chemists and physicists still regarded as the best mechanical explanation of the electrolytic process when all facts are fully considered. Dr. Kahlenberg then points out that the dissociation hypothesis is widely connected with van't Hoff's theory of solution. Upon the assumption of Arrhenius that free ions, part-molecules charged with electricity exist in an electrolyte and act like so many molecules, the general statement which van't Hoff had made for solutions was upheld,—namely, that dilute solutions having the same temperature and the same osmotic pressure contain the same number of dissolved molecules.

Dr. Kahlenberg then contends that the facts presented by Arrhenius in his original article in 1887 are not sufficient to serve as a basis for the assumption of electrolytic dissociation in solutions, and that while isolated facts may here and there be interpreted by means of the dissociation theory, the bulk of experimental evidence gathered since 1897 speaks strongly against the theory. Dr. Kahlenberg refers to his own work published in 1901, in which "a comparison of the feezing-point values with the molecular conductivity at 0°, and also of the boiling-point values with the molecular conductivity at 95°, revealed the fact that there is no such connection between freezing-points and boiling-points of solutions on the one hand, and their conductivity on the other, as is claimed by the theory of Arrhenius. In numerous cases not even a qualitative agreement exists." The objection that all the solutions employed were too concentrated to enable one to use the data to confute the dissociation theory, is met by Dr. Kahlenberg by the statement that the adherents of the theory, among them Arrhenius himself, have repeatedly used solutions as strong and even stronger than the most dilute solutions employed by Kahlenberg.

"Not all the adherents of the theory of electrolytic dissociaciation would be ready to admit with Whetham that the only satisfactory cryoscopic measurements at the extreme dilutions

necessary to test the theory are those of E. H. Griffiths for cane sugar and potassium chloride. It certainly is demonstrated by Griffiths' work that the so-called molecular lowering of the freezing-point of potassium chloride is within very small limits of experimental error double that of cane sugar. This is merely one isolated experimental fact, and it has not yet been shown that the curve representing the change of the molecular-weight with the concentration runs parallel with the curve indicating the change of the freezing-point with the concentration in the case of potassium chloride within the range investigated by Griffiths. Nor has this parallelism between freezing-point and molecular conductivity been rigidly demonstrated for the solutions cryoscopically examined by Loomis. If one were therefore to take the attitude of Whetham, there would be no unobjectionable experimental evidence whatever on hand at present upon which to base the claim that freezing-points and molecular conductivity are related as held by Arrhenius."

"No one expects the gas equation to hold strictly for a normal solution or even for one considerably more dilute; but what one has a right to expect from the modern theory of solutions is, that with increasing concentration a solution should behave at least qualitatively as a gas does with increase of pressure. And this requirement is clearly not met, since while all gases behave alike under increase of pressure (so that van der Waals has been able to express their behavior by means of his well-known equation) solutions, as has been shown, often behave in a manner opposite to that of gases, and this, too, frequently in solutions that cannot be termed concentrated. This demonstrates, then, that the van't Hoff law is at best only approximate and must be supplied with great care."

Dr. Kahlenberg then calls attention to the fact that, while the molecular conductivity increases with the volume in very many cases, yet in some instances, like that of the caustic alkalies, the molecular conductivity first increases and then decreases with the volume. In still other cases, the molecular conductivity diminishes or remains practically constant as the volume increases. The only cases which conform to the requirements of the dissociation theory, even in general trend, are those in which the molecular conductivity increases with the volume.

Concerning the statement that it is the high specific inductive capacity of the solvent that causes electrolytic dissociation, Dr. Kahlenberg say that "in the face of the fact that numerous exceptions to the Nernst-Thomson rule are known, and that no quantitative relation between the conductivity of a solution and the dielectric constant of its solvent has ever been established, it would appear that the Nernst-Thomson rule is really untenable." Whether a solution will conduct electrolytically or not depends upon the specific character of both solute and solvent, and is quite independent of the dielectric constant of the solvent.

The approximately additive properties which some solutions exhibit has frequently been regarded as evidence in favor of the dissociation theory. "Additive properties, however, are known to occur where electrolytic dissociation is out of the question, and hence these properties cannot be used as an argument in favor of the Arrhenius hypothesis. In the case of solids the molecular heat is approximately equal to the sum of the atomic heats; in liquids, insulators as well as electrolytes, the molecular volumes and molecular refractions are approximately equal to the sum of the atomic volumes and atomic refractions respectively, and yet who would assume dissociation in these cases on that account?"

The color of aqueous electrolytes has been ascribed to the color of the ions. "Copper ions are blue; nickel ions are green; cobalt ions are red, etc. But I have shown that benzene solutions of copper oleate, nickel oleate, and cobalt oleate are also blue, green and red respectively, and that these solutions are as good as insulators as benzene itself. Furthermore, the cobalt oleate solution turns blue when heated, and on cooling turns red again, exactly as aqueous conducting solutions of cobaltous salts. It has, therefore, been demonstrated that the color of solutions is independent of their power to conduct the current, and cannot be used as an argument in favor of the dissociation hypothesis."

Instantaneous reactions sometimes occur between insulating solutions, and hence cannot be regarded as taking place between the free ions present.

A strong argument against the hypothesis is that it cannot be harmonized with the law of mass-action. The agreements obtained by Ostwald in his application of the dilution law to solutions of weak organic acids are only very rough, and to electrolytes *par excellence* it cannot be applied at all; Rudolphi's and van't Hoff's amended formulæ are purely empirical.

The power of coagulating colloids has been ascribed to free ions, but such power is not confined to solutions of electrolytes.

It is in the realm of non-aqueous solutions that, according to Dr. Kahlenberg, the theory proves especially impotent. We now know of such solutions that conduct electricity even better than aqueous solutions, and yet yield higher molecular weights than those computed from the formulæ of the solutes. The researches of Walden or liquid sulphur dioxide are quoted as being particularly conclusive.

The theory has been applied to fused salts. The author questions the validity of such application to what are practically 100 per cent. solutions; the hypothesis is avowedly only strictly true for infinitely dilute solutions.

Dr. Kahlenberg then develops his own views in the following paragraphs, which are quoted in full:

"I should not like to close these pages without indicating the direction which in my opinion further investigations on solutions must take. All treatises on physics and chemistry seek to draw a sharp distinction between the processes of solution and chemical action; the former is commonly described as purely physical in character, the latter as more deep seated and as caused by specific attraction termed chemical affinity. It is well known that some substances react chemically (using that term in its usual sense) with each other, and again others do not; and that the rate of interaction and the final condition of equilibrium reached are subject to influences of temperature especially, but also to pressure and concentration. The same may be stated of the process of solution. Some substances dissolve each other, others do not; and again, the process, like that of chemical action, is subject to influences of temperature, pressure, and concentration. Energy changes, such as thermal changes, electrical changes, expansions and contractions, and evolutions of light are known to accompany the processes of solution as well as those of chemical action. With the exception of the mass, the properties of chemical compounds are never exactly equal to the sum of the properties of the constituents entering into them; the same is true of solutions. Furthermore, those properties which are approximately additive in character in the case of chemical compounds are also approximately additive in the case of solutions. Examples of such properties are the molecular volume, molecular refractive power, and specific heat. Again other properties like, for example, the optical rotatory power, the specific inductive capacity, which are not additive in chemical compounds, are also not additive in the case of solutions.

"In fact the only distinction between a solution and a chemical compound is that the latter conforms to the laws of definite and multiple proportions and the former does not. But it must be borne in mind that so-called pure chemical compounds are obtained only by subjecting the total reaction products to certain purifying processes, such as evaporation, distillation, sublimation, crystallization, washing, extraction, etc. All of these processes put the reaction products, which are in general solutions (using that word in its broader sense) under special duress, as a result of which there are obtained as cleavage pieces of these solutions, as it were, phases whose

composition remains constant through a greater or lesser range of temperature, pressure and contact with other phases. *The process of solution and chemical action are then identical in character, and chemical compounds are merely the cleavage pieces of solutions placed under special stress or duress represented by the so-called purifying process.* The process of solution is thus the general case of the interaction of bodies, union resulting when the specific attraction, commonly called chemical affinity, between them, is under the existing conditions sufficient to cause an interpenetration, a fusion or blending of their masses, as it were. Furthermore, adhesion, imbibition, absorption, adsorption and imbibition are also due to the same specific attraction which causes solution and chemical action. Adhesion is really to be regarded as an unsuccessful attempt at solution. Thomas Graham was unquestionably right when he stated that from adhesion to solution and chemical action there is every stage of gradation. It is scarcely necessary to add that these views were also entertained by numerous other scientists of note, among whom Bunsen was especially prominent. The truth of this view will force itself upon the mind of any one who seeks to work out the problem of solutions in the laboratory rather than at the writing-desk.

"It need hardly to be emphasized that the recognition of the importance of the laws of definite and multiple proportions, which have been found to hold in so many cases of phases that maintain their composition for considerable ranges of alterations of temperature, pressure and nature of co-existing phases, is not at all affected by the above considerations. The discovery of these laws has been of inestimable value in analytical and synthetic work, and in systematizing our knowledge; but it is a mistake to think that they necessitate the conclusion that the processes of solution and chemical action are different in character and are caused by different agencies. The fact that the quantities of similar solutes which must be added to equal quantities of a given solute to produce solutions of the same vapor tension, are to each other as the quantities in which such solutes unite with other substances to form stereotyped chemical compounds, constitutes a strong argument for regarding the processes of solution and chemical action as identical in character.

"It thus becomes evident that in investigating solutions we must begin with the most concentrated and end with the most dilute; the latter will appear simply as a limiting case. So, for instance, the change of the vapor tension of solutions with the concentration must be studied from the strongest solutions obtainable to the dilutest that can still be measured throughout the range of temperatures at which the solutions can exist at all. And this work must be done for a large number of solutes in a large number of solvents. Such data being at hand, the equations expressing the changes of vapor tension with temperature and concentration may be written. Work of this character has only barely begun; but judging from the results at hand, analogous substances will exhibit similar behavior; and though it is not to be expected that one equation will serve for all solutions, similarities between the equations holding for different solutions will not be lacking."

The abnormal values of molecular weights of substances in solution as determined by change of vapor tension, freezing or melting-points is according to Kahlenberg, merely a measure of the affinity between solute and solvent, and has nothing to do with any supposed dissociation; the calculation of molecular conductivities is founded upon the erroneous supposition that the solvent plays no part in the conduction. Recent determinations of osmotic pressures by the author have similarly shown that these depend on the nature of both membrane and liquids, and are by no means in accordance with the requirements of the gas laws. Here, again, as in solutions, ***affinity*** is the determining quantity.

"Of late years work in physical chemistry has been largely directed to the study of the effects of temperature, pressure and concentration on the progress of chemical reactions, and properly so. In this intensive work it has at times been forgotten, however, that affinity must exist before union can take place, and that temperature, pressure and concentration are simply to be regarded as modifying factors aiding or retarding the tendency of affinity. By some it is even deemed as somewhat old-fashioned to talk about affinity. But upon the distinct recognition of affinity, and a careful investigation of the laws governing it, clearly depends the future progress of chemistry, physical chemistry, and physiology. We must learn to measure affinity quantitatively; but in order to take into account the phenomena of morphology as they confront us in crystals, but particularly in living beings, we need to learn to study the direction as well as the strength with which affinity acts under given conditions. Finally, the question why certain solutions, molten salts, etc., conduct electricity and others do not, will probably not be answered until we can tell why a stick of silver conducts electricity and a stick of sulphur does not. These questions really involve a better understanding of the relation between electricity and gross matter, a problem which is apparently being attacked with promise by J. J. Thomson and his co-workers. Until we have more light on this subject we can hardly hope for very material improvements of our views of the nature of electrolytic processes."

* * * * *

The paper of Dr. Kahlenberg elicited a long and animated discussion. W. C. D. Whetham, in a written communication, pointed out that the problem of the nature of solution was independent of the difference between electrolytes and non-electrolytes, which was all the theory attempted to explain. The ions must be conceived as being free from each other, not from all chemical combination, in order to explain the observed phenomena of conduction.

Prof. Abegg also sent in a written communication. Prof. Kahlenberg's reasons for doubting the theory are merely facts which cannot be explained by the Arrhenius theory alone. The latter explains the behavior of dilute aqueous solutions, where the non-ionized molecules are, as a rule, not associated, and not cases where association occurs, such as in non-aqueous solutions. The author further overlooks the fact that conductivity depends on the mobility of the ions, as well as on the degree of ionization. The theory can be harmonized with the law of mass action, as the work of Rothmund and Drucker and Jahn has shown.

Dr. G. Rudorf referred to the question of the color of solutions, and showed that on the assumption that the molecule of copper sulphate has nearly the same light-absorbing properties as the ion, all difficulties disappear. The theory quite explains the reactions mentioned in benzine solution, if only very few ions are assumed to be present.

Dr. T. M. Lowry said that Prof. Kahlenberg's criticisms were mostly expended on a theory which was not the dissociation hypothesis as conceived to-day. The theory does hold good for concentrated solutions, only we are not yet able to measure the degree of ionization in such cases. The gas laws are not quite true for moderately dilute solutions, because some of the molecules of the solutes are in combination, and not free. He dealt at length with the various points raised by the author.

Dr. H. Borns showed that Prof. Kahlenberg's capital mistake was that he attacked everything that had ever been said or done with the theory. He ignored recent modifications of it that the ideas of hydrolysis, complex ions, and association have caused.

Dr. H. Sand, (in a communication) dealt with the differences between the theory of Clausius and that of Arrhenius, and discussed some of the approximate assumptions that lead to numerical disagreements in the applications of the latter.

Dr. C. H. Desch discussed Prof. Kahlenberg's experiments with copper oleate in benzine solution, and described some experiments of his own bearing on the subject. He thought

the difficulties raised by non-aqueous solutions very serious ones.

F. S. Spiers drew attention* to the theory of Traube which gave numerical expression to some of the conceptions of solution apparently held by Prof. Kahlenberg, and explained the Arrhenius coefficient i in terms of the affinity between solute and solvent.

HYDROGEN-OXYGEN CELL.

F. J. Brislee communicated a paper entitled "The Potential of the Hydrogen-Oxygen Cell," which was read by Dr. F. M. Perkin. Measurements of the potential of a hydrogen-oxygen gas cell with platinum electrodes and a normal acid solution show different results when the oxygen electrode is charged with oxygen electrolytically, or charged by passing oxygen gas through the liquid. Experiments were made to determine the influence or hydrogen peroxide, ozone, and persulphuric acid upon the oxygen potential. The results obtained showed that the addition of hydrogen peroxide lowered the oxygen potential, while addition of ozones and potassium persulphate raised it.

By employing platinum electrodes of extreme thinness (prepared by depositing platinum on glass), the same potential of the combination was obtained independently of the method employed for charging the electrodes. This potential agreed well with that calculated from the Helmholtz formula.

In the discussion which followed, H. L. Joly referred to the effect of persulphates, and said that in accumulators it had been proved that their presence did not account for the rise of E. M. F. on charge.

Some Present Problems in Technical Chemistry.*

BY PROF. W. H. WALKER, PH. D.

Technical chemistry may be regarded as the performance of a chemical reaction or series of reactions on a scale sufficiently large and by a method sufficiently economical to enable the product to be sold at a profit. The problems which confront the investigators in this field of endeavor may, therefore, be divided into two classes, according as they pertain to the chemical reaction involved or to the process to be employed in carrying on this reaction. The first division is pure chemistry, even though the results of the solution be utilitarian; the second is chemical engineering. There is in reality no dividing line between the two. It would be difficult to find an investigator in the field of pure science who does not hope, and indeed believe, that the results of his labor will at some time prove of value to humanity; may ultimately be utilitarian. On the other hand, few, if any, chemical manufacturers would admit that in solving their chemical problems they do not utilize the most scientific methods at their command. The research assistant is in the last analysis utilitarian; while the successful chemical engineer is pre-eminently scientific.

Probably in no country have the problems confronting the chemical industries been so successfully met as in Germany; yet Germany does not excel in chemical engineers. Engineering enterprises, mechanical, civil and electrical, as well as chemical, are carried on as successfully in England and America as they are in Germany, and still the latter leads the world in her chemical manufacturers. The explanation for this lies in the fact that Germany pays the greatest attention to the first class of problems, as above divided, and recognizes that pure chemistry is inseparably connected with her industries; that the application of new facts and principles follow rapidly when once these facts and principles are known. Most of her problems in technical chemistry are first considered problems in pure chemistry and studied in accordance with recognized methods of modern research by men fully trained in pure science. If these men are also chemical engineers the ultimate solution of the problem is proportionately hastened; but they are first of all men trained in the spirit and methods of scientific research.

In general, an investigation may be prompted by either or both of two incentives; either by the pleasure to be derived from achievement and the love of scientific study for itself, or, by the hope that from the investigation some immediately useful result may be obtained. Yet between the product of the first motive—pure chemistry—and the ultimate result of the second—technical chemistry—a difference does not necessarily exist. The fact that a piece of work is undertaken and carried on with the predetermined purpose of applying the results to a practical or commercial end does not in itself render it any the less a study in pure chemistry. The method of thought and action employed will be that of the investigator in pure science, whatever the ultimate object may be. To make the result of the work an achievement in technical chemistry an important contribution must then be made by the chemical engineer, in order that the conditions forming the definitions of the term "technical chemistry" as already stated may be fulfilled.

In trying to point out, therefore, some of the important problems in technical chemistry, no attempt will be made to distinguish between the part which must first be played by pure chemistry in their solution, and that which will still remain to be done, by the chemical engineer, to make this contribution utilitarian.

There is always a tendency to measure the importance of a subject by the extent of one's knowledge of it and the depth of the interest one has in it. In order, therefore, that we may obtain a proper perspective, we must consider a problem important in proportion as it affects the greatest number of people; of moment according as the results of its solution will be far-reaching in their effects, or be but of local benefit.

From this point of view the first industry to demand attention is the manufacture of fertilizers. In the last ten years the product of this industry in the United States alone has increased from 1,900,000 tons to 2,900,000 tons, an increase of over 50 per cent. This increase is probably more marked in America than in the older countries of Europe, because the necessity of replenishing the virgin soil was there reached long ago, while with us it is only begun. The magnitude of the industries which are dependent directly or indirectly upon agricultural products is so well recognized that it needs no discussion here. That the supply of crude material from which plant life derives its nourishment should be maintained is therefore a source of responsibility for the present, as well as for future generations. Of this, as of every great industry it may be said that the supply of raw material for to-morrow is a problem for to-day.

Dr. H. W. Wiley, of the United States Department of Agriculture, has pointed out the surprisingly large amount of potash, phosphoric acid and nitrogen which is yearly taken up by the agricultural crops alone. The average percentage of ash in all of the important crops has been accurately determined and their percentage composition in respect to potash and phosphoric acid is known. In addition to this we have a satisfactory knowledge of the percentage of albuminous matter contained in the more important agricultural products. From these figures and the reports of the United States Department of Agriculture we can calculate the amount of potash, phosphoric acid and nitrogen consumed each year. Allowing a value of 4 cents a pound for potash, 5 cents for phosphoric acid, and 12 cents for nitrogen, the total value of these ingredients for a single year amounts to the enormous sum of $3,200,000,000. To be sure this is not all removed from the farm and lost to the soil; but that which remains in the form of straw and manure is but a small percentage of the whole. Straw is generally burned, while the soluble salts of the manure heaps are often allowed to leach out and go to waste. When in addition we consider

* An address delivered before the International Congress of Arts and Sciences at St. Louis.

the terrible waste involved in the modern methods of sewage disposal, where, instead of being returned to the soil, these valuable constituents are carried to the ocean, the net loss of these chemicals can be easily appreciated.

Of these three most important ingredients making up a fertilizer for general purposes, phosphoric acid alone seems to be at hand in practically inexhaustible quantities. Slag, rich in phosphoric acid from certain metallurgical processes is already much used as a source of the material. Fresh deposits of phosphate rock of such enormous extent are being brought to light almost every day that our supply of this material may give us little immediate concern.

Although the Strassfurt region of Germany may continue to ship undiminished quantities of potash salts, the second important ingredient of a fertilizer, the world's supply cannot be said to be on a perfectly satisfactory basis until independent sources are developed. In the year 1902 the value of the potash salts imported into the United States amounted to 4½ million dollars. The recovery of potash from wood ashes, while once an important industry, must diminish as the value of hard wood increases. While there are doubtless natural beds of potassium salt still to be discovered, the time seems rapidly approaching when we should render more readily available the great amount of potassium distributed throughout the mineral kingdom. Rhodin had already accomplished much toward this end when he showed that feldspar could be made to yield the greater part of its potash when it was heated with lime and common salt. Clark has found that when the mineral leucite, with its 21 per cent potassium oxide is heated with ammonium chloride, the potassium is converted into chloride and is easily separated from the melt. If this reaction could be extended to orthoclase and the ammonia recovered by treatment with lime, the enormous quantity of potash contained in this mineral would be at our service.

It is, however, to the supply of available nitrogen that the greatest importance attaches. The sodium nitrate producing countries of South America exported last year 1,300,000 tons, a large percentage of which came to America. Egypt and the Southwestern United States have nitrate deposits, but of their extent and value little is as yet known. Of the other form of available nitrogen, ammonia, our main supply is at present from the destructive distillation of coal. Although the introduction of by-product coke ovens has increased this supply, our domestic production is now not over 40,000 tons a year.

In the atmosphere, however, we have a never-failing source of nitrogen which needs only to be converted into other forms to be of the greatest value. It is interesting to note that even as long ago as 1840 this same problem was the subject of considerable experimentation and the basis of several technical processes. In this year there was erected in France a plant for the manufacture of potassium ferro-cyanide, which depended on the atmosphere for the supply of nitrogen, and which at one time turned out almost a ton of product per day. From this time until the present, the utilization of this inexpensive and inexhaustible supply of raw material has been an attractive field, and has held the attention of many investigators. It had long been known that while carbon and nitrogen alone could not be made to unite, the union was effected when these elements were brought together in the presence of a strong alkali. The technical difficulties in the way of successfully applying this reaction seem to have been the rapid destruction of the retorts and the loss of alkali through volatilization. With the advent of cheap electricity and the consequent development of the electric furnace, this idea was made the basis of further work. The destruction of the retorts was largely overcome by generating the heat within the apparatus rather than without. When a non-volatile alkali was used to eliminate the loss from this source and a higher temperature maintained, it was found that a carbide was formed as an intermediate product and that nitrogen readily reacted with the carbon thus held in combination.

Among the investigators who have thus far taken advantage of this reaction may be mentioned the Ampere Chemical Co., located at Niagara Falls, and the group of men represented by the Siemens and Halske Co., of Berlin. The former first produces a carbide of barium and then converts it into barium-cyanide by passing over it air from which the oxygen has either been removed or converted into carbon monoxide. Robert Bunsen long ago showed that by using steam the nitrogen in an alkaline cyanide may be converted into ammonia. In this case barium oxide would be left to be returned to the furnace, and to continue the cycle. When advantage is taken of the process discovered by Professor Ostwald, by which ammonia is converted into nitric acid through the medium of a catalyzing or contact agent, the production of nitrates by way of the cyanide reaction is easily foreseen.

The Siemens and Halske Co. prepared, in addition to cyanide and ammonia, by use of the carbide-nitrogen reaction, a new compound in technical chemistry, calcium cyanamide. In contradistinction to the cyanides the nitrogen of this compound is available for plant food and can take the place of the more common nitrogen salts in commercial fertilizers. The technical difficulties in the way of the economic application of these processes are doubtless very great, but when one considers the advance which has been made in the last five years he has ample reasons to believe that it will not be a great while before the synthetic preparation of the cyanides, ammonia and nitric acid from atmospheric nitrogen will be on a commercial basis.

The old reaction by which nitrogen and oxygen were made to unite through the agency of a high potential electric discharge has been made the basis of a process for the manufacture of nitric acid by the Atmospheric Products Co., operating at Niagara Falls. For agricultural purposes it is proposed to absorb the nitric acid thus formed in milk of lime, and so produce an exceptionally cheap product. There still remains much to be done before this can be called a technical process.

A very much less technical, but so far as our knowledge at present goes, a more promising method of fixing atmospheric nitrogen in the form of nitrates is through the agency of bacteria. While it is true that one group of bacteria has the power of breaking down nitrates with the production of nitrogen gas; there are other groups which are equally able to absorb elementary nitrogen with the production of nitrates. A great deal of excellent work has recently been done by the United States Department of Agriculture with the result that cultures for the artificial inoculation of the soil may now be obtained in considerable quantity. It has been found that these bacteria when grown upon nitrogen freemedia may be dried without losing their high activity. When immersed in water they are easily revived. A dry culture similar to a yeast-cake, and of about the same size, can thus be sent out and used to prepare a fluid in which the original nitrogen fixing bacteria may be multiplied sufficiently to inoculate a number of acres of land. The amount of material thus obtained is limited only by the quantity of the nutrient water solution used in increasing the germs. Field experiments have shown the wonderful activity of these bacteria in fixing atmospheric nitrogen and the splendid crops which may be grown upon what would otherwise be almost sterile soil.

In this one problem of our future supply of available nitrogen for agriculture as well as general manufacturing purposes, we note the aid which technical chemistry draws from the other departments of natural science. The electrical engineer and biologist have already contributed a great share in its solution. There remains, however, no small amount of work for the technical chemist to perform before the desired end is reached.

(To be concluded.)

ANALYSIS OF CURRENT ELECTROCHEMICAL PATENTS.

BY GEORGE P. SCHOLL, PH. D.

ELECTRIC FURNACES AND FURNACE PRODUCTS.

Process of Reducing Aluminium or other Metals.—H. S. Blackmore, Mount Vernon, N. Y. Patent 775,060, Nov. 15, 1904. Application filed August 22, 1904.

The invention relates particularly to the production of aluminium from its oxide, but covers in general the idea of liquifying refactory oxides by dissolving them in a readily fusible metallic oxide or mixture of such oxides, and then subjecting the liquid bath thus obtained to electrolysis in such a manner that only the metal desired is obtained, while the oxides acting as a solvent are not decomposed. In the case of aluminium in particular, the inventor takes oxide of lithium and oxide of calcium in the proportion of four of the former to one of the latter, which he fuses by the action of an alternating current, so as not to decompose them. After the fusion of these oxides is complete, he adds oxide of aluminium to the bath, which is stated to readily dissolve, and then subjects the bath to the action of a direct electric current for the purpose of producing metallic aluminium. The apparatus for carrying out the electrolysis is shown in longitudinal vertical section in Fig. 1. It consists of an iron box *A*, lined preferably

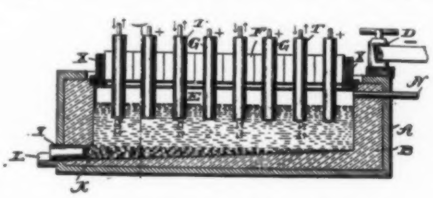


FIG. 1.—ALUMINIUM APPARATUS.

with carbon *B*, and covered by an insulating cover *X*, through openings in which pass the carbon electrodes *G* and *T*. The box forms the cathode, while the electrodes *G* serve as anodes. In starting the apparatus an alternating current is passed between the alternate carbon electrodes *T*, and the carbon lining of the box *A*, and arcs are produced by bringing the electrodes close to the carbon lining. Lithium and calcium oxide in the required proportion are then fed in and fused, the electrodes being gradually separated further and further, as the molten material accumulates in the vessel. Aluminium oxide is then introduced into the bath, and a direct electric current is passed between the carbon anodes *G*, and the carbon walls of the vessel *A*, for the purpose of electrolyzing the aluminium compound. The metal accumulates on the bottom and is withdrawn through tap hole *K*, by moving plug *T*. Instead of using the above solvent bath for the oxide of aluminium, fused lithium-glucinum oxide can be used in cases where low specific gravity of the bath is required. It is stated that when lithium and calcium oxides are fused together as described above to form the solvent bath for aluminium oxide, the solution of the latter takes place without formation of aluminates. By adding copper oxide with aluminium oxide to the solvent bath, copper aluminium alloys may be produced by electrolysis. The inventor claims that by the above described method he effects an economy in the cost of reduction by substituting the less expensive alternating current for melting purposes, in place of the direct current, and that the solvent mixture, viz., lithium and calcium oxides, are fusible with the expenditure of less energy than is required to maintain the fusion of the more expensive and more resistant fluoride compositions employed heretofore. Another advantage claimed is that the solvent action of the molten oxide bath is more than three times that of the fluoride bath, whereby the volume of solvent necessary to liquify a given quantity of oxide of aluminium is largely reduced, with the further advantage, therefore, of a saving in energy to keep a given quantity of the solvent in the state of fusion. Particulars about the yield of the operation, current density ,etc., are not given.

Process of Electrically Treating Materials.—W. S. Franklin, South Bethlehem, Pa. Patent 775,031, Nov. 15, 1904. Application filed Dec. 3, 1900.

The process is described as applied to the treatment of iron ore and glass, and it is carried out in a furnace, the lower portion of which is formed in the shape of a pear-shaped chamber. The furnace was described and illustrated in ELECTROCHEMICAL INDUSTRY, Vol. II., page 32. Resistance heating is used by filling the furnace chamber with a molten electrical conductor, such as slag or glass, and passing the current between a carbon electrode arranged in a layer around the circumference of the furnace chamber and another carbon electrode in the form of a rod, which is arranged vertically, and either dips into the molten conductor, thus heating it entirely by resistance, or is raised above its upper surface, in which case the heat of the arc developed between the electrode and the surface of the conductor will be added to that developed by the resistance of the conductor. When applied to the reduction of iron ore, the molten conductor is preferably slag, the charge of ore, coal, limestone, etc., being fed in separately, and the reduced iron collects on the bottom of the furnace, whence it can be drawn off by a suitably arranged tapping hole. When the furnace is used for the purpose of melting glass, glass itself serves as the molten conductor, and the raw materials are fed in in suitable proportions. They become melted on their way down and are fused and form glass when they reach the surface of the molten conductor. The form of the furnace as shown in the specification, when used for the manufacture of glass in the manner described above, is open to the objection of the contamination of the glass by carbon from the electrodes.

Electric Furnace.—R. Raddatz, Milwaukee, Wis. Patent 775,282, Nov. 15, 1904. Application filed June 23, 1899.

The electrodes in this furnace are arranged at an obtuse angle to each other and are movable. Their ends are covered by a hood formed of a highly refractory material, so that the arc between them, the substance immediately under treatment, and the supply of incoming material are protected. The material under treatment is supplied to a hopper from which it escapes on an endless belt which carries it into the vicinity of the electrodes. An electromagnet is used to deflect the arc upon the material under treatment. Provision may also be made for an opening in the cover for the purpose of introducing a stream of air, gas, oil or vapor for deflecting the arc. The stream of air, gas, etc., may carry solid particles with it, either of the same material as that under treatment or others, the purpose of introducing these particles with the current of air or gas being primarily to insure the perfect formation and the persistence of the arc, and to permit a greater separation of the electrodes than would otherwise be feasible. Details of mechanical arrangements are described and illustrated for the automatic regulation of the electrodes to compensate for their burning away, in order to render the action of the furnace perfectly uniform. The material is intended to be fed in a comparatively thick or heavy layer, so that the unfused portion laying beneath that which is fused would protect the bed or apron from the excessive heat. The furnace may be used for either direct or alternating current. When direct current is used, however, the positive electrode wears away more than the negative one, and it is therefore

stated to be advantageous to feed the material under treatment through or under the arc from the negative towards the positive electrode, as on account of the positive being the hotter, the greatest heat will be available for the finishing work or the complete fusion of the material.

Electric Furnace.—A. C. Higgins, Worcester, Mass. Patent 775,654, November 22, 1904. Application filed April 4, 1904.

The invention is primarily to be applied for the intermittent fusion of highly refractory materials, where the furnace has to be torn down after each batch of material is finished. Two serious disadvantages have manifested themselves with this type of furnace. The first was the question of providing a satisfactory refractory lining, for which purpose carbon was mostly used, which was, however, expensive, inasmuch as the lining had to be destroyed each time, and it was necessary to carefully and laboriously build it up again for the next run. There was also considerable time lost in discharging the furnaces and getting them ready for the next run. As shown in Fig. 2, the furnace is of the arc type, the electrodes 10 and 11 being held stationary in heads 12 and 13, to which the conductors 14 and 15 are connected. The crucible is constituted by the shell 16, which fits into the base ring 17, the latter being mounted on the base, 18. The base is raised or lowered by a suitable mechanism, such as a direct-plunger hydraulic elevator, with plunger 19. As the material under treatment is melted, the carbide is lowered until it is full, or the run is completed. A hood, 20, is provided for the purpose of confining the gases and forcing them to escape through the chimney 21, feed opening being provided. The shell 16 is made of boiler plate, and is slightly smaller at the top than at the bottom. A water-distribution pipe, 25, is mounted near the top of the furnace on brackets, 26, and is provided with a number of small holes through which water for cooling purposes is sprayed on the shell. The waste water escapes through pipe, 24. The numerous small streams of water playing upon the shell thus flow over the latter's surface in a continuous sheet, which covers the entire surface of the shell, and chills whatever molten material comes in contact with it. The layer of chilled material thus serves as a lining for the molten mass, the temperature of the lining being kept so low that it will not injure the shell. The water is therefore not confined at the points of the greatest heat, and the danger of explosions is reduced to a minimum. Moreover, the entire flow of the water is constantly exposed to the supervision of the furnace operator, who can regulate the flow of water to suit the conditions of the run, and receives ample warning of any danger to the shell. At the end of the run the furnace is easily taken apart by lifting the shell, with the fused and hardened mass in its interior, off the base and replacing it by another, after which the operation can be commenced again. The furnace seems to be primarily intended for the production of the artificial abrasive, alundum, in which case bauxite, or the amorphous oxide of alumina is fused in it.

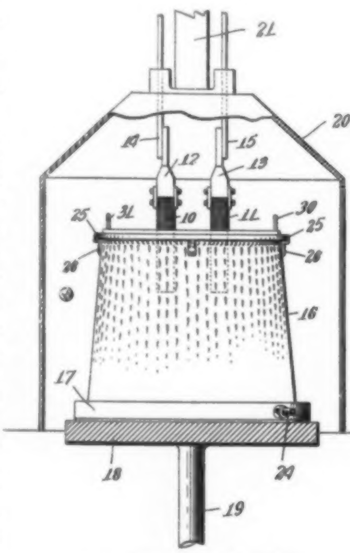


FIG. 2.—ALUNDUM FURNACE.

Electric Heater.—E. P. Weggen, Jefferson City, Mo. Patent 775,714, Nov. 22, 1904. Application filed April 22, 1904.

The heater described is stated to be of peculiar value to boot and shoe factories for the purpose of heating the tools used for removing wrinkles from the toes or tips of boots and shoes. It comprises a casing filled with asbestos, within the head of which is mounted a cap-shaped vessel of iron, lined with copper, and surrounded by a coil of resistance wire of German silver. Suitable arrangements are made for introducing different lengths of this resistance wire into the circuit, and thus regulating the temperature.

Electrolytic Production of Metals and Compounds.

Manufacture of Barium Hydrate.—F. Jahn, Ridley Park, Pa. Patent 775,752, November 22, 1904. Application filed Sep. 5, 1903.

The process depends upon the electrolysis of a solution of barium sulphide in a cell with three compartments divided by porous diaphragms, the outside compartments being anode, and the middle one the cathode compartments. The vessel is lined with an insulating material, such as cement, and the electrodes are preferably iron plates. The inventor has found that the anode plate should have a much larger surface than the cathode plate, good results being obtained with an anode about four times as large as the cathode. This is the reason for providing two anode compartments and only one cathode compartment. In carrying out the process a strong solution (about 35 per cent.) of barium sulphide is introduced into the anode compartments, while the cathode compartment is filled with a weak solution of barium hydrate. The surface of the solutions is preferably covered with a layer of coal oil, in order to exclude the air. The current density should be rather high, about 9 to 15 amperes per square foot of anode surface, and 40 to 70 amperes per square foot of cathode surface. As a result of the electrolysis, sulphur is stated to be precipitated at the anode in an insoluble state, thereby converting the barium sulphide into hydrate. At the beginning of the process the sulphur thus precipitated at the anode is redissolved by the sulphide liquor with the formation of polysulphides until the whole of the sulphide is converted into the polysulphide. After this has taken place, the sulphide is precipitated and not redissolved. When the anode liquor contains from 75 to 80 per cent. of the dissolved barium as hydrate, the electrolysis is stopped. With electrodes of the above size, the inventor finds that he can obtain about 30 per cent. of the hydrate, which is formed in a very pure state, from the cathode compartment, the other 70 per cent. of the hydrate being at the anode. From the anode liquid the hydrate can be obtained by crystallization, the precipitated sulphur being also recovered.

Process of Extracting Gold Ores.—H. R. Cassel, London, England. Patent 775,597, November 22, 1904. Application filed May 22, 1903.

The process aims at providing means for the solution and extraction of precious metals from their refractory ores, such as tellurides and sulphides, or from slimes containing them, without previous roasting. The process is carried out in a round wooden tank, provided with a vertical central shaft, which carries a stirrer. Around the periphery of this vat there are arranged a series of carbon rods or plates, placed in a vertical position. They are alternately connected to the negative and the positive pole of a source of current. The pulverized ore is converted into a pulp by mixing it with a solution consisting of water containing either a cyanide and a bromide, or a cyanide, a bromide and a chloride. Bromates and chlorates may also be added, the different ores requiring variations in the composition of the electrolyte as well as in the current. The following composition of the electrolyte is stated to be usually employed with good results for the treatment of one ton of ore: one ton of water, 100 pounds of sodium chloride, 3 pounds of sodium bromide, and 2 pounds of

potassium cyanide. If the chloride is omitted and the bromide alone is used in conjunction with the cyanide, the quantity of the bromide must be increased in order to make the electrolyte sufficiently conductive. The presence of the bromide has, however, been found very desirable in order to effect a high extraction of over 90 per cent., and when it is omitted, the results are negative. The chloride is added mainly in order to make the electrolyte better conductive. The pulp is charged into the vat and is kept agitated, while an electric current is simultaneously passed through it. A high-current density, exceeding 10 amperes, and preferably about 40 amperes per square foot of anode surface is used, about 100 amperes per ton of ore. It is stated that the current density may be varied according to the nature of the ore. No density, however, is to be employed which would cause a substantial deposit of gold upon the cathode, as would happen if the current density was too low. An ore of about the following composition is stated to be well adapted for treatment by the process: silica 64 per cent, alumina 27.5 per cent., lime 1.0 per cent, oxide of iron 3.5 per cent, sulphide of iron 3 per cent, oxide of manganese 0.5 per cent magnesia, gold, tellurium 0.5 per cent. It is stated that the extraction is more rapid and more complete, and that more metal is dissolved than would be the case were the current not employed; the increased extraction amounting in some instances to over 40 per cent. The cyanide alone is decomposed, practically all the haloid salts being found at the end of the operation. After electrolysis the pulp is filter-pressed, or the solution separated otherwise from the solids, after which the gold is precipitated by zinc, or by any other method. The recovered solution may be used on a fresh batch of ore, after sufficient cyanide has been added to replace the amount decomposed. The extraction is stated to be generally complete in about twelve hours.

Electroplating Isolated Designs on Vitreous Surfaces.—L. Blower, New York. Patent 774,976, November 15, 1904. Application filed March 23, 1904.

The process consists in fusing a mixture of pulverized metal and flux in the desired design upon the vitreous surface and then increasing the thickness of the metallic deposit thus obtained by electrodeposition. The metallic powder is mixed with a suitable flux, the resulting mixture being mingled with a suitable medium, such as silicate of potash. The desired design is then laid out with this mixture on the vitreous surface, and the article then fired so as to fuse the mixture into the design. During this operation of firing the metal and the flux are melted, and the flux unites with the vitreous surface and is separated from the metal in such a degree that a metallic surface is exposed suitable to form an electric conductor in the subsequent plating process. The article is then introduced into a plating bath and the surface of the design connected as cathode, the anode, of course, being made of the metal which it is desired to plate on the design. Suitable provision is made to connect the various parts of the design to the electrode. After the electrodeposition has attained the desired thickness, the articles are removed from the bath and the surface of the electroplated metal may then be polished, burnished, frosted, or finished in any desired manner. The process is chiefly intended for decorating or applying labels to articles of glass, porcelain, china, etc.

STORAGE BATTERIES.

Protective Coating or Covering for Storage-Battery Plates.—A. Meygret, Paris, France. Patent 776,192, Nov. 29, 1904. Application filed June 29, 1903. Renewed April 6, 1904.

Protective Covering for Storage-Battery Plates.—A Meygret, Paris. Patent 776,480, Nov. 29, 1904. Application filed June 29, 1903. Divided and re-filed July 27, 1903. Renewed April 6, 1904.

The two patents relate to a protective covering for storage batteries, in a similar manner to that described in the inventor's patent 756,176, abstracted in ELECTROCHEMICAL INDUSTRY, Vol. II., page 206. The protective covering described in the first one of the above patents is composed of a solution of tetraacetate of cellulose or tetraacetate and tetrabutyrate of cellulose. The plate after being filled with the active material is dipped into either one of these solutions, which cover it with an elastic protective film. The solution described in the second patent, which is to be used for the same purpose, is composed of tetrabutyrate of cellulose, without admixture of any other body. The protective covering thus formed is pierced with a number of fine needle points or fine gashes, in order to allow the electrolyte to reach the active material beneath it. This elastic coating prevents the active material from becoming loose and detaching itself from the plate.

Battery Charging Apparatus.—H. G. Pape, New York. Patent 775,732, Nov. 22, 1904. Application filed May 17, 1904.

The apparatus consists of a flexible cord which is to be attached to a lamp or other socket connected with a source of current. At the other end of this cord there is a connector provided with two female terminals, into which a similar connector with male ends connected to the battery terminals is to be inserted. A current indicator is used in order to ascertain the proper pole-connection. The device is particularly intended for charging small pocket-batteries for audiphone sets.

GALVANIC ELEMENTS.

Method of Converting the Energy of Fuel into Electrical Energy.—Hugo Jone, Chicago. Patent 775,472, Nov. 22, 1904. Application filed Nov. 18, 1901.

The above process is a simplification of the inventor's first patent which was described in ELECTROCHEMICAL INDUSTRY, Vol. II., page 326. (See also Vol. I., page 586; Vol. II., page 18.) It consists essentially in the production of an electric current in a galvanic cell by using tin as the positive and carbon as the negative pole, the electrolyte being molten caustic potash. Mercuric oxide is used as the depolarizer, which becomes reduced to mercurous oxide or metallic mercury during the operation, and is regenerated in a separate vessel. The tin is oxidized to oxide of tin, and the latter is constantly reduced in the apparatus by means of fuel gas passed into the cell. The fuel gas is generated in a gas producer in about the same manner that water gas is generally made, omitting, however, preferably the impregnation of the gas by hydrocarbons. The battery is illustrated in vertical cross-section in Fig. 3.

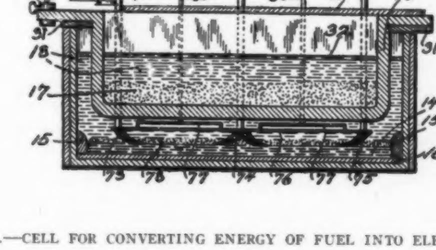


FIG. 3.—CELL FOR CONVERTING ENERGY OF FUEL INTO ELECTRICAL ENERGY.

It consists of a vessel made of some material unaffected by caustic potash, upon which rests by means of a flange the square, porous carbon vessel, 10. This vessel serves as the negative plate and contains the mercuric oxide, 17. A flat pan, 16, with a ledge, 15, rests on the bottom of the outer vessel and contains the metallic tin which constitutes the positive pole. The fluid, 18, in the inner and the outer vessel is a watery solution of caustic potash, kept at an elevated temperature. The solution is covered with a layer of paraffine, 32, to prevent absorption of carbon dioxide and oxygen from the air. The reducing gas is introduced through pipe, 68,

heated in coils, 69, and supplied to the cell by pipes, 71, 72, and 73, which are provided with suitable jets, 73, 74, and 75. The shape of the jets is preferably such that the gas is brought into contact with as much oxide of tin, 78, as possible. The several pipes and jets are made of enameled copper. The reducing gas, being kept under gasometer pressure, passes through the coils and is heated to nearly the temperature of the coils, and is then delivered into the liquid through the distributing pipes and the jets, and reduces the stannous oxide to metallic tin. The metallic tin is thus recovered and the generation of the electric current continues uninterruptedly. The electromotive force of a cell of this kind is stated to be 1.03 volts, the current strength of a cell of the capacity of one gallon of liquid being 12 amperes, when the external resistance is .04 ohm. The gas which rises in the liquid before being oxidized accumulates in the inverted pans, 77, whence it escapes through pipes, 88. It is claimed as an advantege that the cell can be stopped easily by simply lowering the temperature. This stoppage may also be brought about by discontinuing the supply of gas, in which case the tin is gradually covered by a film of oxide which retards and finally almost entirely stops the battery reaction. The energetic action of the battery is largely accounted for by the acid properties of the oxide of tin, since even the more electropositive metal, which has no acid properties, would dissolve in alkali less rapidly, or not at all. Cadmium may be substituted for the tin, the latter being, however, preferred.

Galvanic Element or Battery.—Paul Brandt, Schöneberg, near Berlin, Germany. Patent 775,892, Nov. 22, 1904. Application filed April 20, 1904.

A small battery, as employed for pocket lanterns, etc., and consisting of a receptacle with several partitions. Each of the compartments contains a tubular cylinder of zinc, in the interior of which cylinders there are arranged carbon rods surrounded by a substance adapted to suck up a comparatively large quantity of the electrolyte. The electrodes in the different compartments are connected in series by strips of metal embedded in a layer of pitch, asphalt or the like at the bottom of each compartment.

Battery Case.—R. H. Wappler and F. H. Wappler, New York. Patent 777,457, Dec. 13, 1904. Application filed April 20, 1904.

This invention relates to the contsruction of a compact battery case for the use of physicians, etc., the cover and base of which case are connected by hinges and hold the various cells securely in place.

MISCELLANEOUS.

Thermopile.—J. A. Lyons and E. C. Broadwell, Chicago. Patent 775,187, Nov. 15, 1904. Application filed Dec. 9, 1903.

Thermopile Elements.—Same inventors. Patent 775,188, Nov. 15, 1904. Application filed July 6, 1903. Renewed July 6, 1904.

The thermopile described in the first patent is heated by a Bunsen burner arranged in the center, and consists of a number of layers of concentric rings, the spaces between which are filled with alternating layers of negative and positive electrically-conductive and thermally-resistive substances. The positive elements are preferably composed of finely divided metallic copper, each particle of which is electroplated with bismuth. The negative elements are composed of cuprous sulphide alloyed with about 18 per cent. of metallic antimony for the purpose of increasing the electrical conductivity. The inwardly directed surfaces of the rings are convex and highly polished, while the outer convex surfaces are painted with lampblack. The object of the second patent is to obviate the use of metals or alloys in thermopiles, as an instance of which a pile is described consisting of bars or plates of a mixture in about equal proportions of iron sulphide and lead sulphide, which are used alternately in conjunction with bars or plates of copper phosphide. To the latter an excess of phosphorus has been added so as to insure complete conversion of the copper into phosphide during the process of its formation and varying proportions of copper sulphide or tin telluride may be added to it.

Process of Manufacturing Ammonium Formate.—H. Pauling, Brandau, Austria. Patent 776,543, Dec. 6, 1904. Application filed April 2, 1902.

The process consists in subjecting a gas mixture containing hydrogen, nitrogen and carbon monoxide, together with steam, to electric non-luminous or brush discharges in the presence of porous contact substances, such as spongy platinum. Ammonium formate is then obtained according to the equation: $2N + 3H_2 + 2CO + 2HO_2O = 2HCO_2(NH_4)$. The presence of porous contact substances is essential, for no ammonium formate is formed if the mixture is exposed to non-luminous or brush discharges alone. Preferably Dowson gas or a mixture of water, gas and nitrogen is used, but instead of this a mixture of air and the gas mixture mentioned above may be used, in which case, however, the air has been previously exposed to electric discharges in order to transform the nitrogen present in it into nitric acid.

Process of Heating Air.—H. Pauling, Brandau, Austria. Patent 777,485, Dec. 13, 1904. Application filed August 12, 1902.

The process relates particularly to the production of oxides of nitrogen from atmospheric air by heating it to a very high temperature with a view of dissociating it. For this purpose the air or gas to be heated is conducted alternately from both sides into a chamber provided with a heat-generator, for which purpose electric arcs, struck between carbon electrodes, are utilized. The heating chamber is situated between two regenerator chambers, patterned after those employed in open hearth furnaces. The cold air in the beginning of the operation is passed into the heating chamber and then travels through the checker work of one of the regenerators, where it parts with its heat. When this regenerator has been heated enough, the current of air is reversed so that the air to be treated passes through the regenerator before entering the heating chamber and thus arrives in the latter already in a highly heated condition The other regenerator is heated in the same manner, the process being continued until the temperature of the regenerators nearly or quite equals that of the heating chamber. A diagrammatic plan of the apparatus is given in Fig. 4. It is made of the best fireproof material, adapted to withstand a temperature of 2,500° and comprises a heating chamber, 1, and two regenerators, 2 and 3, separated by the bridge, 4. The heat is furnished by a number of carbon electrodes, 5, which extend transversely into the furnace. Conduits, 6 and 7, lead into the lower parts of the respective regenerators,

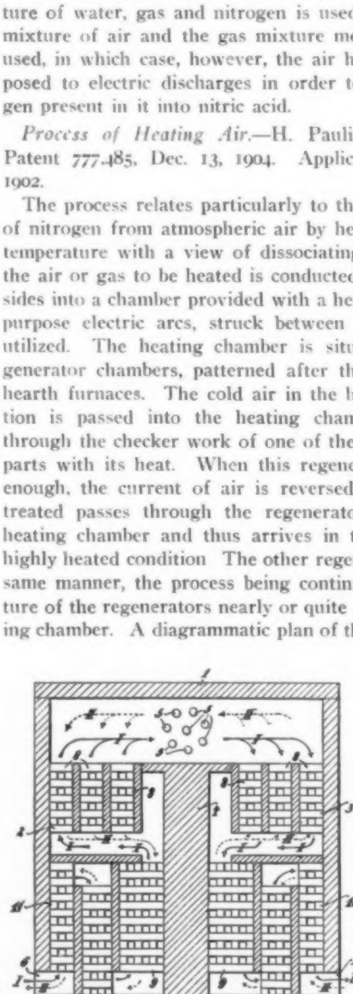


FIG. 4.—APPARATUS FOR HEATING AIR.

through which conduits the air under treatment alternately enters and passes out. Each regenerator is preferably divided into a number of compartments, 8, 9, 10 and 11. The course traveled by the air current from its entrance through the conduits, 6 and 7, to its exit through these conduits is indicated by the arrows I. and II. When the temperature desired has been obtained, the current is interrupted and the electrodes withdrawn, after which air can be driven in suitably reversed directions through the furnace for reaction purposes until the requisite high temperature does not exist

any more, after which the electrodes are reintroduced and the process repeated. It is stated that by this method the nitrogen and the oxygen of the air may be made to combine, forming nitrogen dioxide, which latter may be converted into nitric acid in any suitable manner.

Process of Manufacturing Nitric Acid.—H. Pauling, Brandau, Austria. Patent 777,486, Dec. 13, 1904. Application filed August 12, 1902.

The first step of the process consists in treating a certain quantity of atmospheric air by either ozonizing it by dark electric discharges, or by heating it to a temperature of 1,000° or 1,200° C., at which temperature nitric oxide is decomposed into nitric dioxide and nitrogen. The air thus treated is then subjected to electric-spark discharges, the amount of water necessary to convert the nitrous compounds formed into nitric acid being added by introducing steam and fresh air or hydrogen or gas mixtures containing hydrogen, such as water gas, after the electric-spark discharges have been interrupted. When a body of air at normal temperature is subjected to the effect of a discharge of electric sparks, nitric oxide, nitric dioxide and ozone are produced. Nitric oxide and ozone require considerably more energy for their formation than nitric dioxide. As, however, ozone cannot exist at temperature above 350° C., and nitric oxide splits up into nitrogen dioxide and nitrogen at approximately 1,000° C., neither one of the two can be formed if the spark discharge takes place in air heated above that temperature. The current is supplied by an induction coil connected with a dynamo; the ozonizing of the air is effected by dark electric discharges, the air being conducted through a receptacle enclosing a condenser, which consists of two parallel glass plates covered with metal on the sides forming the adjacent faces or those facing each other and connected with the induction coil. The air is then conducted into another receptacle and there subjected to electric-spark discharges, the apparatus being fitted, if desired, with the regenerative features described in the preceding specification.

Apparatus for Electrically Treating Gases.—K. Birkeland, Christiania, Norway. Patent 775,123, Nov. 15, 1904. Application filed June 15, 1903.

The apparatus is intended for carrying out the inventor's process for the production of nitrogen compounds from atmospheric nitrogen, described in ELECTROCHEMICAL INDUSTRY, Vol. II., page 399 and 507. In order to obtain the arc in the shape of a disc at right angles to the lines of force of the magnetic field, the inventor has found it advantageous in the case of currents of high voltage, *f. i.*, 10,000 volts, to have the poles of the electrodes at a distance of a few millimeters. If direct currents are used, there will be a great number of such arcs formed in succession, without any mechanical interruption of the current, the number being up to several hundreds per second. If alternating current is used, there will be two systems of arcs, one-half of them being formed on the under side, and the other on the top side of the electrodes. The electrodes are preferably provided with strips at their ends, these strips being preferably in the shape of arrow-heads. If a current of six hundred volts or less is used, either direct or alternating, it has been found desirable to arrange the electrodes in such a way that their poles approach and recede from each other in rapid succession, sufficiently to come into contact with each other. Various constructions are outlined for effecting this vibratory movement.

RECENT METALLURGICAL PATENTS.

ALUMINIUM.

An attempt of reducing aluminium from alumina without the use of the electric current is made by H. S. Blackmore (United States patent 778,100, Dec. 20). He uses as reducing agent acetylene mixed with magnesium vapor. Porous aluminium oxide is heated in a retort to bright redness. A current of acetylene is then passed through molten magnesium, "regulated so that it will carry in suspension the magnesium vapor in about equivalent proportions." The acetylized magnesium vapor is then passed through the hot porous aluminium oxide. For the resulting reaction the author gives three equations. The first is

$$Al_2O_3 + C_2H_2 + Mg = 2Al + 2CO + MgO + H_2$$

This reaction is stated to develop sufficient heat to allow the following reaction to go on

$$2Al_2O_3 + 3C_2H_2 = 4Al + 6CO + 6H$$

The third equation given by the author is the sum of the first two

$$3Al_2O_3 + 4C_2H_2 + Mg = 6Al + 8CO + MgO + 8H.$$

It is difficult to say how well this process, if practicable at all, would work on a large scale in competition with the extremely simple electrolysis of alumina dissolved in a fluoride bath. The proposal is certainly interesting—even from a very restricted electrochemical standpoint, since the reducing agents used—acetylene and magnesium—are electrochemical products.

R. Fortun and E. Semprun (778,025, December 20) patent a solder for aluminium or aluminium alloys, including the following ingredients, silver, aluminium, zinc and tin, "at least a portion of the silver, aluminium and tin being phosphorized, and at least a portion of the zinc being sulfurated."

COPPER.

A patent of P. Weiller and A. Weiller (775,548, November 22) refers to the separation from their ores of copper, silver, lead, mercury, and all other metals adapted to be precipitated from an acid solution by means of sulphureted hydrogen. The special features are the use of neither coal nor air blast in the process. "The reducing agent and fuel for generating the high temperature required is metallic iron, the oxygen being supplied by means of a powerful oxidizing agent which is added." The crushed ore is mixed with iron filings and saltpeter, the proportions of the latter two being preferably one to one; but if the ore contains combustible substances, such as iron sulphide or disulphide of iron, the quantity of iron-filings must be proportionately more than that of saltpeter. The mixture is placed in a small furnace and ignited, whereupon the metal is reduced and fused and descends to the sole of the hearth. If the ore requires a higher temperature or stronger oxidation for washing, then a chlorate is added to the mixture.

GOLD AND SILVER.

There exist certain alluvial deposits, consisting for the most part of sand containing a greater or smaller percentage of magnetic iron oxide in a granular or pulverulent state, with which fine particles of free gold are associated, or to which they adhere in a manner which renders mechanical or hydraulic separation impracticable. T. J. Lovett (775,043, November 15) proposes to treat these deposits by wet magnetic separation. The magnetic iron oxide thus separated and carrying gold is subjected to lixiviation with cyanide of potassium. The gold is then precipitated in any suitable way, while the tailings from the leaching vats are "substantially pure magnetic iron oxide which may be dried if desired, and shipped in a granular state to the furnace, or it may be briquetted for smelting. The concentrated iron oxide in a granular or pulverulent state is in the best condition for electric smelting."

C. H. Rider (776,424, November 29) extract gold and silver from ores by crushing and treatment in a series of tanks, one-half of which are the leaching tanks, the other half the precipi-

tation tanks. The tanks are connected by pipes running from the top of one tank into the bottom of the next one; the object is to pass the gases which are developed in one tank from its top to the bottom of the next tank for the purpose of agitation. The ground ore is first placed in the leaching tanks with a solution containing 3 to 5 gallons of sulphuric acid and 15 to 20 gallons of nitric acid per 100 gallons of water. This dissolves the content of silver in the ore. The solution is then removed from the leaching tanks to the precipitation tanks, and a fresh solution containing 5 gallons of nitric acid and 10 gallons of hydrochloric acid per 40 gallons of water, is brought into the leachmg tanks to act on the undissolved ore. This dissolves the gold, and by adding this solution to that now in the precipitation tanks, an immediate precipitation of the silver is caused as silver chloride. The gold is afterwards precipitated by a saturated solution of ferrous sulphate. This brings the gold down in the metallic state.

A greater number of patents refer to details of construction of leaching or filtering apparatus. W. S. Jones (777,379, December 13) patents an ore-leaching vat with perforated pipes in the bottom for passing air into the solution, both for agitation and for supplying the oxygen required for the solution of the gold in the cyanide solution; the main feature is that the bottom of the tank is divided into sections which are separate and air-tight from each other laterally, and the air is introduced into each section independently of the others.

F. H. Long (775,405, November 22) effects a repeated circulation of the entire charge of mixed ore and cyanide solution in successive portions through a contracted channel by injecting into the channel an air-blast of sufficient force and volume to maintain the circulation of the charge, and to revivify the cyanide and clear the ore while the circulation persists.

J. J. Berrigan (775,414 and 775,509, November 22) passes the comminuted ore and the solution through a series of agitators, making use of centrifugal forces. The ore is first conducted by a conveyor into a descending stream of solution so that both enter the first agitator well combined and with a large amount of air intermingled with them. A revolving liquid ring of solution and ore is established in all agitators, and finally in the separator in which the enriched solution is separated from the ore by centrifugal forces. The thorough agitation, with its continuous introduction of oxygen into the solution, are intended to accelerate the solution of the precious metals.

L. E. Porter (773,221 and 773,222, October 25) patents two forms of slime-washer. By means of a revolving tubular shaft with lateral arms, he introduces compressed air into the tank for agitation; the same device is also used for introducing fresh wash-water. The enriched solution filters through gunny-sacking at the top of the tank and flows over the edge into a launder. The sands and slimes are discharged through a tube in the conical bottom of the tank.

D. C. Boley (774,736, November 15) employs a tank with a perforated bottom to which is secured a lining of textile fabric "by means of folds of the fabric itself, the edges of the fabric being secured to the sides of the tank, whereby overlying battens above the fabric are dispensed with and perforation of the fabric obviated." The tank is filled with the sands, slimes and cyanide solution, and air is introduced into it upwards through the bottom. When the gold is dissolved, the supply of air is stopped; the contents are allowed to settle, and finally fresh solution, containing no gold, is introduced through the bottom to replace the enriched solution.

H. R. Cassel (773,473, October 25, and 774,349, November 8) describes details of construction of filtering apparatus, by means of which the liquid is filtered off from the pulp by suction in a tank containing filter cells, while simultaneously the pulp is agitated between the cells.

Evidence of the increasing interest of Australian cyanide engineers in the use of filter presses, is a patent of W. A. Pritchard (776,084, November 29) for a pressure-filter for slimes. The mixture, as a whole, is fed into the lowest end of the main chamber of the apparatus and the liquids forced out through the filtering mediums, while the mixture during its process of exhaustion is concurrently conveyed upward by revolving propeller plates, and the undissolved residue is finally discharged at and from the top of the chamber.

ZINC.

C. S. Brant (775,359 and 775,360, November 22) patents two devices for preventing lead from coming into the spelter during the process of distillation. Fig. 1 shows one device in which the lead is separated from the zinc vapors by means of a filter bed or the like, composed of broken clay crucibles or other chemically inert non-combustible or refractory material.

FIG. 1. FIG. 2.
DISTILLATION OF ZINC.

The zinc vapors produced pass through the upper aperture in the extremity of the nozzle. The filter bed arrests and throws down the lead, while it allows the zinc vapors to pass through to the condensing chamber. The lead flows back into the retort by way of the lower aperature in the extremity of the nozzle. Fig. 2 shows a second device of the same inventor. In this case he provides a lead—interception chamber.

MISCELLANEOUS METALLURGICAL APPARATUS.

W. B. Simons (778,149, December 20) patents an apparatus for the treatment of pyrites, the object being to facilitate the driving off of the sulphur fumes for the manufacture of sulphuric acid. The apparatus consists of a series of superposed grates. The pyrites are introduced at the top and while burning are passed from one grate to the next. In this way, they are sufficiently agitated to effect complete combustion and cause the sulphur fumes to escape.

Frequently in the operation of blast furnaces there occurs a violent expulsion of gases from the top, caused either by an explosion of gases or by the slip of the charge. As a result, the fine ore dust is carried out in large quantities. J. Coyne (777,498, December 13) describes details of construction by which the dust thus driven from the furnace may be separated from the gases collected so as to be returned in a suitable form to the furnace.

U. Wedge (777,577, December 13) describes details of construction of a roasting furnace, the principal objects being the ready application or removal of the arms carrying the stirring blades and the provision of means for cooling these arms.

C. H. Repath and F. E. Marcy (776,085, November 29) patent details of construction of rabble arms and rakes for roasting furnaces so that any rake when broken can be removed and another one substituted without disturbing the other rakes or without first cooling the furnace.

S. V. Huber (777,509, December 13, and S. M. Guss, 775,563, November 22) patent valve mechanisms for furnaces.

C. Raapke (777,746, December 20) patents a reversible hearth converter "comprising an oblong converter, means to turn the converter about its transverse axis, a passage communicating with the interior of the converter and substantially at right angles to its longitudinal axis of rotation, chambers, communicating with each other and surrounding said passage, a blast-pipe connected with said chambers and with the bottom of the converter, the converter being provided with a suitable charging and with a suitable delivery opening, one of the said chambers being provided with a side-opening and suitable covers to close the said openings."

E. Kratochvil (777,112, December 13) patents a water-dispersing rotary device through which blast furnace gases are passed for the purpose of cleaning them for use in gas engines.

J. C. Fox (777,725, December 20) patents details of construction of cupels of bone-ash, as used by assayers. The base of the cupel instead of being made flat, as heretofore, is hollowed out or recessed slightly on the under side, so as to form a space between the bottom of the cupel and the floor of the muffle, the effect of this space being that the litharge, when it reaches the bottom of the cupel, cannot pass into the floor of the muffle, but will be caused to spread laterally until the full absorption of the cupel is reached.

E. Keller, A. Ferrell, and K. W. McComas (777,421, December 13) patent details of construction of assay-button droppers; E. H. Fosdick (773,203, October 25) patents details of construction of a blow-pipe.

SYNOPSIS OF PERIODICAL LITERATURE.

A Summary of Articles on Electrochemistry and Allied Subjects Appearing in American and Foreign Periodicals.

INDUSTRIAL APPLICATIONS.

Titanium.—A very long and interesting account of experiments on the production of titanium and titanium alloys from rutile and titanates in the electric furnace is given by W. Huppertz in Nos. 17, 18, 19, 21 and 22, 1904, of *Metallurgie*. The great difficulties involved in the problem are due to the very high affinity of titanium to nitrogen and carbon. The rutile used by the author was a product from mines in Virginia, U. S. A., and was of great purity, consisting of 96.26 per cent TiO_2, 2.26 per cent Fe_2O_3 and 1.42 per cent SiO_2. The author first tried to reduce TiO_2 by means of carbon in the electric furnace, but could obtain only a mixture of TiO, titanium, titanium nitride and titanium carbide. He then varied the conditions of the experiment in so far as TiO_2 was reduced simultaneously with the oxide of another metal, carbon being again the reducing agent. Though better results were thus obtained, yet it seems from his experiments that the only possibility to get in this way a metal free from nitrogen and carbon would be to produce a raw metal by Moissan's method and then to reduce it by means of TiO_2. Moissan obtained in this way a metal containing not more than 2 per cent C. The author suggests, however, to modify Moissan's method by carrying out the reduction by carbon in an atmosphere of hydrogen. The author then experimented with calcium carbide as a reducing agent. When he tried to reduce TiO_2 by means of calcium carbide, he obtained only titanium carbide and calcium titanate, but no metallic titanium. The result can be improved, however, if another metal, especially iron, is present. In this case he obtains an alloy which contains really metallic titanium, besides titanium carbide. The author then makes some remarks on the reduction of TiO_2 in the blast furnace, and then passes over to the use of aluminium as a reducing agent. The aluminothermic reaction takes place after the mixture has been ignited according to the equation

$$3TiO_2 + 2Al_2 = 3Ti + 2Al_2O_3.$$

However, the speed of reaction is small; moreover, the excess of heat is not sufficient for completely melting the titanium on account of the high temperature of reduction. The author, therefore, employs external heat by combining the aluminothermic reaction with electric heating. He concludes that by this method, if certain precautions are taken, any quantities of pure titanium may be obtained. Finally, the author employed an electrolytic process with calcium chloride as electrolyte, the titanium oxide being reduced cathodically by the calcium ions. The cell used for this purposse is the strontium metallic furnace illustrated in our Vol. I., page 104. By this method, he succeeded in preparing titanium in form of grains melted together, with a perfect metallic lustre and a brilliant white color. The metal thus prepared is absolutely free from nitrogen and carbon. In a flame, it gives a beautiful light effect, and could therefore be used in pyrotechnics. By the same method titanium alloys can be made, if, instead of TiO_2, titanates, for instance, of iron, copper, etc., are used.

Electric Furnace for Making Glass.—A continuation of the article by J. Bronn on the experiments made by him in continuation of those by Becker and Voelker with electric glass furnaces is given in the November issue of *Electrochem. Zeit.* In the experiments described in the present installment the heat for the smelting of the mass was obtained by radiation from arcs between carbon electrodes. The main trouble experienced was that carbon impurities came into the glass and colored it. He describes various experiments which he made to prevent this, but which were unsuccessful. He obtained the best results with an arc between two cored carbons. When the melting process was going on smoothly, the ammeter and voltmeter needles showed, nevertheless, strong oscillations. The reason was that he used really a combined arc and resistance furnace, since from each electrode, a discharge passed over to the glass, so that part of the current passed through the glass (similarly, as is the case with the Héroult steel furnace). The regulation of the electrodes was rather difficult. The article is to be continued.

Gold.—The *Engineering and Mining Journal*, of October 27 contained an illustrated article by W. E. Greenawalt on chlorination in Colorado. He states that 60,000 tons of ore are mined per month in the Cripple-Creek District, yielding bullion worth $1,901,800. Of these, 40,000 tons are treated by chlorination, 9,000 tons by cyanidation and 11,000 tons by smelting. He claims that with the application of chlorine, as generated by electrolysis, cyaniding will not be able to compete with it, even on the basis of economy. He discusses the various stages of the treatment, namely, sampling, bedding, fine crushing, roasting, chlorination in barrels, precipitation and chlorination of the barrel tailings. The usual barrel charge is said to be:

	Pounds.
Ore	20,000
Water	10,000
Sulphuric Acid (66° B.)	200 to 400
Bleaching powder (33½ per cent Cl)	100 to 200

The acid costs from 1 to 1.25 cents per pound, and the bleach from 2.5 to 3 cents per pound, delivered. Hydrogen of sulphide is used as precipitant.

P. Argall in the *Engineering and Mining Journal*, of November 24, criticises severely the estimate of cost given in the above article. He thinks chlorination cannot compete with cyanidation, and that the day of barrel chlorination is past. To this W. E. Greenawalt replies in the issue of December 15, maintaining his original position. The issue of December 1, of the same journal, contains a second illustrated article by W. E. Greenawalt under the title, "The New Chlorination." He gives a comparison of chlorination versus cyanidation in favor of the former. He points out that in the chlorination process there is no particular difficulty in precipitating the gold to a trace by means of hydrogen sulphide, charcoal or ferrous sulphate. He advocates strongly the introduction of the electrolytic process of making chlorine from common salt into chlorination plants. In connection with this it may be interesting to read the description of the J. E. Greenawalt elec-

trochlorination process in our January issue, 1904, page 24.

Gold and Silver.—An account of some electrolytic experiments with gold and silver sulphide ore is given by M. Vaygouny in the *Electrical Review* of November 5. He experimented with Tonopah ore, which was a grayish quartz ore, containing some galena, pyrite, calcite, silver sulphide and gold, with a gangue consisting mainly of quartz. It also contained a notable proportion of metallic iron introduced in the ore through improper grinding. The electrolyte used contains one to two per cent ferric chloride, 15 per cent to 20 per cent common salt, and one per cent hydrochloric or sulphuric acid. The percentage of extraction of the silver values is of about the same degree, namely, 95 to 97 per cent, whether the solution and ore mass is kept boiling for two or three hours, with constant stirring, or is left in the cold for two to three days, with only occasional shaking. It also does not materially affect the results whether the solution contains only one per cent ferric chloride, and is constantly chlorinated, or oxidized in some way and thus regenerated, or is made up of two or three per cent ferric chloride and is left without chlorination. This is so, however, only so far as the silver extraction is concerned. The thoroughness of extraction of the gold values depends entirely upon the thoroughness of chlorination. By prolonging the time of treatment in cold to three to four days the almost totality of the silver values can be got, provided they occur as sulphide, as chloride or as metal, though this latter is rarely the case in nature. By constant removal by electrolysis of the silver dissolved and consequent regeneration of the solution, and proper stirring of the ore mass, the time of treatment is very much shortened. In most cases, if the ore carries also much gold, a sufficient amount of this metal is also extracted, besides the silver, to pay a large share, if not the whole, of the expenses of the treatment, and this with no more care than is given to the extraction of silver alone. If it be desired to extract the gold values to anything like the thoroughness of the silver, then care must be taken that the solution never lacks chlorine. If this were the case, that is, if any chance were given for the ferrous chlorine, resulting from the action of ferric chloride upon the sulphides in general, to accumulate in the solution to any extent, then the gold, if at all dissolved, would be reprecipitated and would thus remain in the ore mass by the well-known secondary influence of ferrous salts upon dissolved gold chloride. The precious metals dissolved in the solution are precipitated by electrolysis. He finds that when a very small percentage of glue is added to the solution slimy deposit is mostly avoided, the deposit being generally perfectly solid. (This is quite analogous to the case of the Betts lead refining process). Carbon or graphite electrodes are stated to be most suitable.

Zinc.—A method of K. Kaiser for an improved leaching process of zinc from ores is mentioned in *Metallurgie*, No. 7, 1904. After oxidizing, roasting and suitably crushing, the ore is mixed with a sufficient quantity of a solution of zinc chloride so as to change the zinc oxide contained in the ore into oxychloride. The zinc chloride solution may be employed in any strength upwards of 25 per cent. $ZnCl_2$. Very soon after the addition, the mass dries and hardens. It is then again crushed and leached out hot with muriatic acid. This is claimed to give a very complete solution of the zinc contained in the ore, while the quantity of iron dissolved is small. The solution is then purified and electrolytically treated to obtain the zinc. The same issue contains an editorial note in which some doubt is expressed upon the full success of the method.

Separation of Tin and Lead from Tin-Lead Alloys.—The increased consumption of tin during recent years has caused a greater use of tin ores containing lead in tin smelting works, while in electrolytic detinning works, the tin of the tinned iron sheets is impure on account of the solder. Both these conditions result in the production of greater quantities of tin containing lead. L. Peetz discusses in *Metallurgie*, 1904, No. 14 and 16, at length, various processes for separating the lead from the tin. He concludes that the separation of tin and lead is practicable in a galvanic couple or short-circuited cell, in which solid lead oxide serves as cathode and the lead-tin alloy as anode with an alkaline electrolyte at a temperature of over 35° C. The tin from the lead-tin alloy passes into the solution, while the lead oxide is reduced to lead. If the plates of the tin-lead alloy are thick, it is necessary to remove at intervals the layer of spongy lead from the surface from which the tin has been leached out. The author recommends to use alloy plates of not more than 1 mm. thickness, since with thicker plates losses of tin are unavoidable.

Increasing the Speed of Copper Deposition.—It has long been known that the deposition of a metal from its salt by electrolysis depends essentially on the condition that a sufficient number of metal ions are always in contact with the surface of the cathode. For this reason stirring or heating are advantageous, since both means tend to bring new ions to the cathode. In *Electrochem. Zeit.* of November, S. von Maximowitsch describes another method which has the same effect. It consists simply in a horizontal arrangement of the electrodes, the anode being placed above the cathode. Since the solution of the copper salt when giving off copper to the cathode becomes lighter, the light solution rises upwards, and new fresh solution of the copper salt is carried to the cathode.

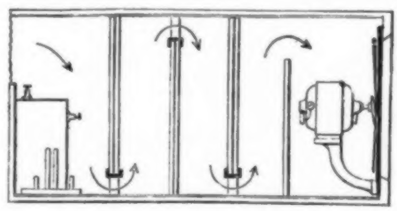


FIG. 1.—OZONIZER.

Ozonizer.—A new ozonizer devised by A. Rosenberg and shown in Fig. 1, is described in the Lond. *Elec. Rev.*, of November 11, as follows: Each element of the ozonizer consists of a thin sheet of highly insulating material, such as micanite, against which are applied, on either side, sheets of copper gauze having 40 meshes to the inch. These sheets are connected alternately to the two poles of the step-up transformer, which gives a potential difference of 4500 volts, this having been found by experiment to be the best pressure for the purpose. It will be seen that the current of air drawn through the ozonizer by the fan is constrained by the arrangement of the elements, acting as baffle-plates to pass over the whole of the ozonizing surfaces, which have an area of nearly 4 square feet in the apparatus in question. As at each corner of each mesh of the gauze the wire is necessarily bent so as to form an elevation, which may be regarded as a rounded point, there are 230,400 such points to every foot of the ozonising surface, or a total of over 900,000. From each of these a discharge takes place upon the surface of the dielectric; but, owing to the extreme sub-division of the discharge, there is no sparking whatever, and hence no nitrous compounds are formed. The apparatus is capable of ozonising 30,000 cubic feet of air per hour, with the expenditure of 60 watts, including the losses in the rotary converter. The actual production of ozone is said to amount to 250 grams "for an expenditure of 1 unit" (measuring 1 kw-hour).

Theoretical and Experimental.

Aluminium Anode.—The valve action of the aluminium anode has been the subject of an investigation by F. Fischer, who studied especially the question whether this effect is due simply to large (ohmic) transition resistance or whether it is a polarization effect. The results of his investigation are published in *Zeit. f. Elektrochemie*, November 11. The author concludes from his experiments that the valve effect is primar-

ily dependent on the temperature. Whenever the temperature rises so much that the liquid in the pores of the film begins to boil, the film is broken and the valve action is destroyed. With dilute sulphuric acid and electrodes of ordinary construction, the film breaks down under ordinary conditions at 30 volts. When, however, the electrode was constructed in such a way that the heat produced at it, may be easily carried away, the film did not break down until a voltage of about 70° was reached, the other conditions of the experiment being unchanged. Finally, if with the latter construction of the electrode, artificial water cooling of the electrode was employed, the film did not yet break down at 200 volts. The counter e. m. f., due to the anode film, is, according to the author, mainly due to the ohmic transition resistance of the film. It is a polarization effect only so far as in the case of ordinary oxygen polarization. The thickness of the films with 12, 24, 35, 72 volts was about 0.05, 0.10, 0.15 and 0.30 mm. respectively, so that the thickness is proportional to the voltage. The film obtained with 12 volts is transparent, that obtained at 24 volts still shows transparency, while those obtained with 36 and 72 volts are no longer transparent and show a shade of grayish green. For the great rigidity and compactness of the film, the author offers the following explanation based on electric endosmosis. Aluminium hydroxide, when suspended in water, migrates toward the anode on account of endosmosis. Consequently a paste of water and aluminium hydroxide gets drier at the anode and gets more wet at the cathode.

Electrolysis With Alternating Currents.—An account of a rather full investigation on this subject by A. Brochet and J. Petit is published in *Zeit. f. Elektrochemie*, December 2. One of the chief results of their experiments is the proof that the effect of a variation of the frequency is not always such as has been supposed. In some cases the efficiency decreases the higher the frequency. In other cases the efficiency increases with increasing frequency, passes through a maximum and then decreases. The same is true for the effect of the current density. The frequency increases quickly with the current density, passes through a maximum and then decreases more or less quickly. When alternating-current electrolysis is considered, the general results cannot be predicted, but must be determined experimentally under special consideration of frequency, current density and the nature of the electrodes. The authors then discuss the question why some metals (Cu, Zn, Ni, Co) are dissolved in KCN as well by direct current as by alternating current; other metals (Ag, Cd, Hg) are dissolved by direct current, but not by alternating current; still other metals (Fe, Pt) are dissolved in KCN by alternating currents only. The authors point out that Cu, Zn, Ni, Co, are-dissolved under the influence of alternating current on account of the ease with which they are anodically dissolved by direct current and the difficulty with which they are deposited cathodically. Ag, Cd, Hg are easily deposited cathodically, and are, therefore, not found to dissolve under the influence of alternating currents. Pt, when mechanically or chemically powdered disolves spontaneously in cyanide solution. Fe is dissolved by the influence of alternating current, but shows quite a distinct and special behavior.

Platinum Salts Made by Alternating-Current Electrolysis.—The fact mentioned above, that platinum dissolves as a result of electrolysis with alternating current, and not with direct current, is made use of in a paper in *Zeit. f. Elektrochemie*, December 2, by A. Brochet and J. Petit, for producing the following reaction:

$$Pt + 2Ba(CN)_2 + 2H_2O = Pt(CN)_4Ba + Ba(OH)_2 + H_2.$$

$Pt(CN)_4Ba4H_2O$ is the salt which has become of special interest during recent years on account of its use for luminescent screens such as used in the study of X-rays and radioactive phenomena.

The Effect of Stirring on Metallic Deposition.—A note by R. Amberg on this subject is published in *Zeit f. Elektrochemie*, of Nov. 4. He claims that all facts observed concerning the accelerated deposition of metals has an effect of revolution of the electrodes which can be explained by Nernst's "theory of the reaction velocity in heterogeneous systems, and by the experimental investigations of Brunner on this theory. According to Brunner, three stages of the phenomenon are to be distinguished in an electrolytic reaction: first, diffusion of the metal towards the boundary surface; second, chemical reaction, namely, discharge of metal irons; third, passage from the liquid into the solid phase which must take place very quickly. If the second process is very slow compared with the diffusion, artificial stirring cannot have any influence on the speed of the deposition, since even without stirring, a sufficient number of ions diffuses to the cathode. For a medium speed of the second process it will be possible to find a limit of the speed of rotation of the electrodes up to which a beneficial effect is observed; this case appears to exist in the electrolytic reduction of certain organic compounds. Finally, it is possible that the second reaction occurs with practically infinite velocity; in this case stirring will always improve the velocity of deposition. The latter case appears to exist for the deposition of metals.

Molecular Attraction.—A former paper by J. E. Mills on this subject was abstracted in our Vol. 2, page 370. The author endeavored to show that the attraction between molecules varies inversely as their square of their distance apart, and does not vary with the temperature, so that the law of gravitation is assumed to hold between the molecules of a substance. On this assumption, he derived an equation according to which the ratio of the difference of the latent heat of vaporization minus the energy spent in overcoming external pressure to the difference of the third roots of the density of the liquid and of the vapor should be constant. The author contributes a further paper on this subject to the *Journal of Phys. Chemistry*, December. He gives some further facts confirming the correctness of the latter equation for normally constituted substances. He also shows that the equation is applicable with equal exactness in the immediate neighborhood of the critical temperature. He deals at some length with an equation of Crompton, discusses the conditions at a critical temperature and deals with the variation of the latent heat of vaporization with the temperature.

Conductivity of Very Dilute Solutions.—Measurements of the electrical conductivity at 18° C. of very dilute (0.0001 to 0.002 normal) hydrochloric acid and nitric acid solutions are described in a paper by H. M. Goodwin and R. Haskell, published in the December issue of *Physical Review*. These very dilute solutions are made by adding to a known weight of water successive portions of 0.01 normal acid. It was, of course, most important to eliminate the effect of the impurities of the water, and two methods of computation of the equivalent conductivity were used by the authors. In both of these, the assumption is involved that the total effect of the acid and impurities on the conductance of each other is produced when a relatively small quantity of acid has been added to the water. The experiments themselves furnish evidence of the correctness of this assumption. In the first method, the increase of the specific conductance over this initial value, divided by increase of concentration, is regarded as the equivalent conductivity at the higher concentration. In the second method, such a quantity, constant at every concentration, is added to the observed values of the specific conductance as will cause the maximum in the equivalent conductivity values calculated therefrom to occur at the lowest concentration at which the total influence of the acid and impurities on each other has been produced. In spite of considerable variations in the observed conductivities due to the use of different samples of water, the corrected values of the equivalent conductivity derived from different experiments, and those computed by the two methods, agree well with each other. New determinations were also made at higher concentrations with hydrochloric acid. The equivalent conduc-

tivity of hydrochloric acid and nitric acid solutions for indefinite dilution are given as 380.1 and 377.0, respectively.

Conductivity of Non-Aqueous Solutions.—The December number of the *American Chemical Journal* contains a paper by H. C. Jones and C. G. Carroll on the conductivities of certain electrolytes in mixtures of two solvents. The authors discussed especially one striking phenomenon, that is, that the curve, giving the conductivity as function of the proportion in which the two solvents are mixed together, shows a minimum, so that the conductivity at this point is decidedly less than the corresponding conductivities in the pure solvents. The authors extended the investigations of Zelinsky and Krapiwin, and of Jones and Lindsay, and show the occurrence of the minimum in conductivity in three substances—cadmium iodide, sodium iodide and hydrochloric acid in mixtures of methyl alcohol and water. The dissociation—as determined from conductivity—of sodium and potassium iodide and potassium bromide in 50 per cent methyl alcohol was found to be greater than that in water at the corresponding dilution. The phenomenon of the occurrence of the minimum is shown to depend primarily upon the decrease in fluidity which results when the liquids are mixed. The hypothesis of Dutoir and Aston is proven quantitatively for certain salts in three solvents—water, methyl alcohol, and ethyl alcohol. The hypothesis of Kohlrausch (formation of an atmosphere of the solvent around the ions in solution) is shown to hold for binary electrolytes in methyl and ethyl alcohols. A hypothesis correlating conductivity, association, and viscosity (or fluidity) is proposed, and is shown to hold for all the cases available for discussion.

Electrolysis of Potassium Acetate.—A reply to the recent paper of H. Hofer and M. Moest (mentioned in our December issue, page 501) is published by F. Foerster and Piguet in *Zeit. f. Elektrochemie*, December 2.

Batteries.

Formation of Storage Battery Plates.—Among the quick formation methods of storage battery plates, that of Lucas with perchlorate is well known. In the *Centralblatt f. Accum.* Schmidt-Altwegg describes some experiments which seem to indicate that chlorate is equally suitable. He used an electrolyte of 1.06 specific gravity, consisting of chemically pure sulphuric acid, dissolved in water, with an addition of one per cent potassium chlorate. Positive plates formed by this method are stated to be specially resistive against the bad effects of discharges down to low voltages.

Storage Battery.—*Elektrochemische Zeit.*, of November, contains an article by G. Hommel, giving the results of tests of the "climax" accumulator, made by a German Company. The negative plate is pasted, while the positive is a Planté plate, the large active surface being obtained by pressing out of a solid lead plate, mechanically, a great number of vertical ribs. The remaining central core is 2 mm. thick, while the thickness of the whole plate, including the ribs, is 13 mm. The results of tests are given in forms of diagrams and tables.

Carbon Cell.—In our January issue, 1904 (Vol. II., page 30), we described a carbon cell by J. H. Reed, and in the same issue, page 18, C. J. Reed gave a critical discussion of this cell. *Iron Age*, of December 8, contains now a fully illustrated article from the pen of S. D. V. Burr, under the title "The Dynelectron."

Metallurgy.

Iron and Steel.

Cementation.—Georges Charpy describes in the *Iron and Steel Magazine* for October, some very illuminating experiments on the carbonization of iron by cementation. Filings of soft steel were kept in melted potassium cyanide, and samples taken out at intervals tested for carbon. The amounts found were, at the start, 0.09 per cent, after 48 hours 4.50, after 85 hours 6.72, after 110 hours 6.72. Since the formula Fe_3C calls for 6.67 per cent of carbon, it is quite evident that 85 hours' treatment converts the iron entirely into this carbide—cementite—and chemical tests further confirmed this, the material being dissolved completely in acids, and containing no trace of graphitic carbon. Mr. Charpy also carburized steel by heating it in a current of pure carbonic oxide. Below 750° C., there is free carbon deposited on the metal, while up to 0.28 per cent was found in the metal itself; above 750° no free carbon was deposited, but corban was absorbed up to 0.72 per cent in two hours' treatment. These experiments throw considerable light on the *rationale* of the cementation process, showing how carbonic oxide, by becoming carbon di-oxide, deposits carbon in the interior of the soft iron which it permeates.

Shrinkage.—The cause and the effect of this phenomenon are of vital importance to the scientific foundryman, and are discussed in the October number of the *Iron and Steel Magazine* by that veteran foundryman, Mr. Thomas D. West. As explained in the article, the practical man calls *shrinkage* the reduction in bulk of the metal from the time it is poured until it assumes the solid shape, while he uses the term *contraction* for the reduction in size after solidification takes place, while cooling down to ordinary temperatures. The particular phase of shrinkage discused by Mr. West is the strange fact that when castings are made from pig iron, remelted in a cupola or air furnace, the higher the silicon present, the less the shrinkage, while when making castings from liquid iron, taken direct from the blast furnace, directly the reverse occurs. The proposed solution of this riddle is that the direct metal carries carbon in the graphitic state, while melted, and is expanded in volume thereby, while remelted iron contains only combined carbon when molten, and since both contain the same amount of graphitic carbon when set, the former shrinks the most. It appears to the reviewer that the *explanation* is more mysterious than the facts themselves.

J. E. Johnson, Jr., in the November number of the same journal, discusses Mr. West's proposition and advances the much more reasonable explanation, that the difference is due to the facts that remelted iron contains at least 0.05 per cent more sulphur, and that it is not so hot as direct iron, and has not been so hot.

Nickel.

An interesting occurrence of nickel in an unusual form is described by Herr Stören in *Metallurgie* for September 22. The ore occurs in large quantities at Evje, in Norway, and may be described in general as a nickeliferous pyrite. It consists really of a mixture of pyrite with 20 to 30 per cent of pyrrhotite (magnetic pyrites), and smaller amounts of pentlandite. The pyrite contains 10 to 12 per cent of nickel, the pyrrhotite only 2.5 per cent, the pentlandite 27 to 33 per cent, the mixture 4.5 to 9 per cent. The low percentage in the magnetic pyrites is the particular difference from our Sudbury ores, together with the unusual amount in the pyrites itself.

Zinc.

The Industry in America.—Walter R. Ingalls, the author of the best treatise on zinc ever written, contributes to Dr. Borchers' *Metallurgie* of August 22 a very timely review of the present prospects of this industry in America. No one is better fitted than Mr. Ingalls to discus this topic, and the article, though short, is full of information and suggestion. One of the principal items discussed is the state of the industry in the Missouri-Kansas fields, where undoubtedly the cheapest zinc-ore smelting in the world is being done. The preëminent advantage of thes localities is the proximity of rich zinc ore, and an abundant supply of natural gas. The amount of gas used for smelting a ton of ore has never been accurately measured, but is estimated as 1100 to 1200 cubic meters (38,500 to 42,000 cubic feet), which costs, on the average, 84 cents. However, there is already beginning to be felt a shortage of gas in this district, and some works, as at Pittsburg, Kansas, are already being

changed to burn coal or producer gas. Only four zinc works in the United States manufacture sulphuric acid from their waste roasting-furnace gases, and the necessity of economizing will undoubtedly force many more into this manufacture in the near future. It appears likely, also, that the centers of zinc production may follow the gas fields, rather than the sources of ore supply.

In the same journal for September 22, Mr. Ingalls continues his observations. He calls attention to the carelessness of chemists in overlooking cadmium in the analysis of zinc, since the Joplin ores contain an average of 0.3 to 0.4 per cent of that metal, which may be concentrated to almost 1 per cent in the first zinc drawn from a retort. The mixed zinc concentrates from the Colorado mines are next spoken of. They are treated to a large extent in Kansas—not mixed, however, with the Kansas ores—and by keeping the temperature of the retorts lower than usual, at the cost of not extracting so large a proportion of zinc, the injurious slagging of the retorts by the lead and iron gangue is largely avoided. At one works, these retort residues are smelted down in a shaft furnace to work lead, to recover their lead, gold and silver values. Mr. Ingalls predicts a considerable extension, in the near future, of the electromagnetic and electrostatic concentrating treatment of these and other zinc blende ores.

In the same journal for October 22, there is described what may prove the long-looked-for solution of the difficulties besetting the making of durable zinc distillation retorts. The German patent, 154,536, of March 27, 1901, describes a retort made of a mixture of carborundum, with fire clay as a binding material. Tests have shown that the silicon carbide is not attacked by the zinc vapors, and does not recrystalize at the temperature of the retort furnace, so that the retorts remain dense and strong after 100 days' continuous use. The inventor states that the retorts have better heat conductivity than the ordinary fire clay ones, last much longer and furnish a better output of zinc from the ores treated.

SODIUM.

Amalgams.—A Schüller, in *Metallurgie* for October 22, furnishes us with the first complete and satisfactory knowledge of the possible amalgams of sodium ever published. His investigation was a systematic study of the cooling curves of alloys of these two metals, a diagram being constructed with abscissæ representing the change of composition from Hg_{100} to Na_{100}, and all compositions between of the general formula Na_4Hg_{100-4}. The actual abscissæ represent, therefore, what are called the "atomic percentages" of sodium present. This method of presenting the results has no theoretical advantages over that of recording simply weight percentages, and has the disadvantage of rendering the curve not directly comparable with the usual curves plotted on the more natural and usual system. The author is to be commended for having determined and plotted on his diagram the points of arrest due to solidification of eutectics, as well as the real melting points, and, further, for having added to these horizontal eutectic lines, vertical strokes representing by their length the relative times during which the eutectic temperature remained constant.

Starting with pure mercury, the first eutectic occurs at 0.33 per cent of sodium, with a melting point of — 48° C. (These quantities are estimated from the diagram, the actual experimental figures are unfortunately not given numerically.) With increasing sodium content the melting point rises regularly, until another eutectic appears at 2.45 per cent sodium, melting point 160°, indicated by a knick in the curve of melting points. Thence, the melting points rise nearly uniformly to the very clearly marked maximum of 360°, corresponding exactly to the compound $NaHg_2$, with 5.44 per cent of sodium. Above this, the melting points fall, with a fair regularity to a second well-defined eutectic melting at 20°, and containing 39.46 per cent of sodium. From this point the curve rises nearly linearly to pure sodium, melting at 95°. The above are the only certain conclusions to be drawn from the investigation. A study of small knicks in the melting-point curves leads the author to suspect the presence of $NaHg_4$, $Na_{12}Hg_{13}$ NaHg, Na_3Hg_2, Na_5Hg_2 and Na_3Hg, but the evidence is not satisfactory.

One theoretical conclusion to be drawn from this study is the observation that true chemical compounds are invariably maximum on the melting point curves, and the indeterminate chemical compounds in indefinite proportions, which constitute an ordinary solution, according to Prof. Kahlenberg's views, are characterized by descending or minimum melting points.

PRECIOUS METALS.

Gold.—Two extended papers by M. Merz are published in *Oesterr. Zeit. f. Berg-u. Hütten-Wesen*, 1904, Vol. 52, pages 59, 70, 86 and 99. And in *Metallurgie*, 1904, No. 8, 9 and 10, on the treatment of the gold selenium silver-ores of Lebong-Douck on Sumatra. These ores contain the precious metals in extremely fine distribution. While the latter dissolve well in cyanides if sufficiently crushed, they have a tendency of forming slimes which can be separated only with difficulty from the sands. The author concludes that the ore is a very special one, and that its treatment will have to be different from that employed in South Africa or anywhere. From his experiments, it seems that the decantation process would probably yield the best results.

Silver Coins.—J. W. A. Haagen-Smit describes in *Metallurgie*, 1904, No. 10, a new method for accelerating the process by which in mints the surface of silver alloys used for coins is whitened.

MISCELLANEOUS.

Gas Engines.—An anonymous contributor to the December number of the *Iron and Steel Magazine* gives some interesting up-to-date facts concerning these latest assistants in blast furnace economics. Instances are cited of single engines driving blowing cylinders 80 inches diameter by 60 inches stroke, and delivering 30,000 cubic feet of air per minute at 25 pounds' pressure per square inch. It is only five years since the first small gas-blowing engine was put into operation. The efficiency of such engines, under the varying loads found in practice, may be safely counted on as 25 per cent, which is 150 per cent advance on the best steam boiler and engine plant. The first cost of the plant is somewhere about 50 per cent more than the steam engine plant, but this reduces only slightly the great saving due to the greatly increased efficiency.

If the gas is made in producers, the statement is made that an entirely satisfactory producer, using bituminous coal, has not yet been devised. The Loomis, Mond and Duff, and Schmidt producers are reported as doing fairly well. The gas is always cleaned, prefereably by a water spray in a centrifugal fan. The Cockerill and the Nuremberg are the preferred types of gas engine for blast furnace work.

Pyrometry.—The exact control and measurement of the temperature in a metallurgical process is often of most decisive importance for the economy of its operation. The December issue of *Physical Review* contains a full discussion of radiation pyrometry by C. W. Waidner and G. K. Burgess. After a general exposition of the fundamental principles and methods of radiation pyrometry, the authors discuss in detail the construction of the following instruments: LeChatelier, Wanner, Holborn and Kurlbaum, Morse, Féry. The Holborn-Kurlbaum pyrometer is shown in Fig. 2, where the tip of the filament L of the four-volt incandescent lamp is set to the same brightness as the object whose temperature is sought, by means of a rheostat. When the filament disappears against the bright background, the current through it is a measure of the temperature sought, when the lamp has been calibrated. One or more red glasses are placed before

the eye-piece as the temperature rises above 900° C., and for extreme temperatures, above 1500° C., absorbing glasses or mirrors are inserted in front of the objective. In the Féry thermoelectric telescope shown in Fig. 3, radiation from the source whose temperature is sought is focussed by fluorite lens *F* on one junction of a minute iron-constantan couple in series with a potential galvanometer, whose deflections are proportional to the energy received by the couple, and hence to the fourth power of the aboslute temperature, according

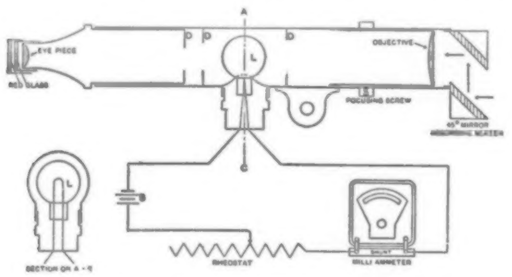


FIG. 2.—HOLBORN-KURLBAUM PYROMETER.

to the Stefan-Boltzmann law, if the radiating source is a black body. This pyrometer, since its indications are given by a pointer over a scale, is readily made recording, a desideratum in many pyrometric investigations. The authors conclude that no one instrument of those discussed can claim a decided superiority as to precision, certainty and ease of calibration, permanence of indications and range. All the instruments are capable of one per cent in temperature measurements in the ranges for which the yare adapted.

The authors conclude their paper by a few remarks on the measurement of very high temperatures, such as produced in the electric furnace, in the Goldschmidt thermit process, etc. Attempts are being made by Nernst and others to estimate these high temperatures by means of chemical phenomena taking place at high temperatures, but this work is still in a preliminary state. For this purpose, therefore, recourse must be had alone to the extrapolation of the laws of radiation which have been verified throughout the range of measurable temperatures. Lummer and Pringsheim have recently taken a single set of observations on an electrically heated carbon tube in an atmosphere of nitrogen, using three radiation methods: photometric (Wien's law); spectrophotometric, and total radiation (Stefan-Boltzman law), the re-

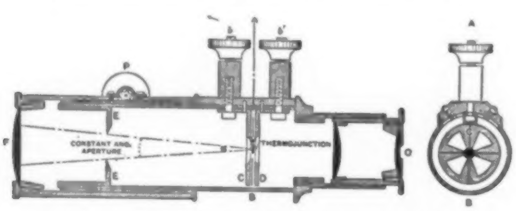


FIG. 3.—FERY THERMO-ELECTRIC TELESCOPE.

sults agreeing to 20° at 2300° C. absolute. From the work of the present authors, it would seem that the radiation laws are still in agreement at the temperature of the arc. Their mesurements have given as the black body temperature of the hottest part of the positive crater 3690°, 3680° and 3720° absolute, as determined with the Holborn-Kurlbaum, Wanner and LeChatelier pyrometers, based on the extrapolation of Wien's law. Féry gets for this temperature 3760° by a method based on Stefan's law. On the basis of these experiments it would seem that the several laws of radiation are in quite satisfactory agreement at the highest attainable temperatures, and thus serve to define the same scale of temperatures.

Book Reviews.

Modern Electro-Plating. By J. H. Van Horne, Chicago: George K. Haslitt & Co. Price $1.00.

This little work of 189 pages and 27 figures, will be a valuable asset in the hands of beginners and platers in country towns. It describes how the work is done and deals with the principles. The book contains a large number of formulæ and other useful information helping the plater out of possible difficulties.

THE OCCURRENCE OF ALUMINIUM in Vegetable Products, Animal Products, and Natural Waters. By C. F. Langworthy, Ph. D., and Peter T. Austen, Ph. D. New York: John Wiley & Sons, 1904. 168 pages. Price $2.00.

This is an extremely laborious and commendably complete compilation of the literature of this subject, giving in each case the reference whence derived. It is, however, more than a mere index of titles and catalogue of analyses; it gives, in many cases very satisfactory abstracts of the articles, enough to inform the reader of the important items of collateral information. The information in this book will be of first importance to anyone making a thorough study of the presence of alumina in soils, mineral waters, articles of food springing from the soil, fertilizers, or, in fact, of agricultural and physiological chemistry in general.

A TEXT-BOOK OF STATIC ELECTRICITY. By Hobart Mason. New York: McGraw Publishing Co., 1904. 155 pages. Price $2.00.

This work sets forth in easily understood terms the basic principles of static electricity. The subject is treated under the headings of I., General Phenomena; II., The Electrostatic ield; III., Capacity; IV., Experimental Measurement of Capacity; V., Instruments Used in Electrostatics; VI., High Potential Static Generators. A very instructive chapter might have been added on "The Application of Static Electricity," which would have clinched many of the principles in the student's mind by showing their usefulness when intelligently handled. However, the technical electrochemist, if he masters thoroughly the principles here so clearly explained, will be able to recognize the ideas and principles utilized in the technical applications of static electricity, and may even have the satisfaction, through this exercise, of foreseeing some applications not as yet discovered.

THE STUDY OF THE ATOM; or, the Foundations of Chemistry. By F. P. Venable, Ph. D., D. Sc., LL. D., Easton, Pa.: Chemical Publishing Co., 1904. 290 pages. Price $2.00.

The treatment is strictly chronological, and therefore strictly logical, because it thus necessarily traces the various stages of the natural development and evolution of the atomic theory. The respective chapters treat of the views of the ancients as to the nature of matter (34 pages), from the Greek philosophers to Dalton (41 pages), the atomic theory (38 pages), the relative weights of the atoms (45 pages), the periodic or natural system (33 pages), studies in affinity (28 pages), valence (27 pages), and recent theories of molecular and atomic constitution (34 pages). It thus appears that the whole field is very thoroughly covered, and the treatment well-balanced; the author is to be particularly commended for avoiding the pitfall which a less experienced teacher might easily have fallen into, viz., that of giving undue prominence and weight to the most recent hypotheses and speculations. Professor Venable has treated these as impartially and as judicially as the rest, and in so doing has increased very much the value of the work. There is no educated person who could not derive both pleasure and profit from a perusal of this book.

A SYSTEMATIC HANDBOOK OF VOLUMETRIC ANALYSIS, or the quantitative estimation of chemical substances by measure applied to liquids, solids and gases. By Francis Sutton, F. C. S., Ninth Edition, revised and enlarged. Philadelphia: P. Blakiston's & Co., 1904. Price, $5.00.

This standard work is so well and favorably known to chemists that no introduction to the name and character of the book is needed. We will, therefore, briefly note the specially valuable features of this new ninth edition.

Part I., devoted to general principles, discusses the methods of calibrating and comparing the burettes, flasks and measuring instruments, of normal solutions and the calculations needed in their preparation and is very clear and complete.

Part II., upon alkalinity and acidimetry, begins with an account of indicators, and these are classified according to the conditions of sensitiveness, and the limitations of individual indicators fully set forth. The titration methods for alkaline and alkaline earth salts are followed by a series of examples of technical examination of some alkaline compounds found in commerce or occurring in course of manufacture, such as soda ash, salt cake, soap, sulphate of ammonia, and ammoniacal gas liquor. This latter subject is especially treated in a very complete way and includes all the important constituents in this complex mixture. The Kjeldahl method so largely used for nitrogen in a wide range of organic compounds, is well illustrated and described, with mention of the most recent modifications. Under acidimetric methods we notice the determination of boric acid in milk, butter, and other foods, the determination of carbonic acid gas in waters, in aerated beverages, and in air, the analysis of commercial tartrates and argols, and of citric acid in lime and lemon juices.

Part III., devoted to analysis by oxidation or reduction, covers the use of permanganate of potassium, of chromic acid, of iodine and thiosulphate, of arsenic acid and iodine, while Part IV. covers the use of silver nitrate solutions and precipitation methods. Part V., covering over 250 pages, or nearly half the space in the book, gives in detail the application of the foregoing principles of analysis to special substances, and includes the whole range of inorganic and organic compounds which can be analyzed by the application of volumetric methods. A few examples from this part of the book will show the wide range of usefulness of the work. Thus, on pages 173-175, we have a variety of methods for the estimation of chlorine in mixtures of chlorides, hypochlorites, and chlorates, a very important problem for the success of electrolytic work at times; on pages 182-183 the methods for the estimation of chromium in ferro-chrome and chrome steel; on pages 254-274 the estimation of nitrates and nitrites under a great variety of conditions and in various mixtures, such as soils, air, waters, etc.; on pages 308-322, the methods for the determination of sugars by the use of Fehling's solution, by mercuric cyanide and other reagents; on pages 351-362, a variety of methods for the determination of zinc in mixed solutions; on pages 368-370, the methods for the determination of formaldehyde; and on pages 378-393, the volumetric methods used in the analyses of oils, fats and waxes, including specially the analysis of butter, genuine and adulterated.

In Part VI. we have the special applications of the volumetric system to the analysis of urine, potable waters, sewage, etc., presented in something over 100 pages. The portion devoted to water and sewage analysis is especially valuable and includes numerous illustrative analyses, showing the varying conditions of the problem of the purity and contamination of water supply.

Part VII. is devoted to the volumetric analysis of gases and covers a full account of the older methods of Bunsen and others, using mercury and the straight Endiometer tube and the new methods of Hempel, Bunte, and Lunge, in which absorption pipettes of various forms are used, as well as endiometer tubes or gas burettes and greater rapidity of action is attained.

The book is indeed a systematic hand-book, as its name states, of all methods which allow of the more rapid analysis which can be carried out by measure as distinguished from the slower gravimetric methods, and is of the greatest importance to the technical chemist or analyst. The book is well printed, and contains a number of good illustrations, but for a laboratory reference book in frequent use ought to be put in a stronger binding.

The Pebble Tube Mill in Metallurgy and Especially in the Cyanide Process.

If a chemical reaction between different substances is desired, it is self-evident that the two substances should be in intimate contact. If one of the two substances is a solid, the logical conclusion would be to reduce the solid to as fine a powder as possible. It is most interesting to note that in gold metallurgy cyanide practice has now come to the same conclusion.

It is well known that former practice in stamping and grinding endeavored to avoid the production of much slime. Quite recently, however, the tendency has become to reduce the ore as fine as possible, with the resulting better extraction of the gold from the ores. A paper by two eminent gold metallurgists, Messrs. Charles Butters and E. M. Hamilton—both well known to the readers of this journal—is most interesting in this respect. This paper was recently delivered before the Institution of Mining and Metallurgy in London, and dealt with the cyaniding of ore at El Oro, Mexico, and especially with the regrinding of sands. The authors have made a very thorough study of the influence of the degree of fineness upon the extraction and upon the best method of pulverizing the ore to a very fine condition.

One chief result is that the extraction becomes better and better with increasingly fine grinding; this "points to the theory that if the whole could be reduced to an absolutely amorphous and impalpable powder, there would be nothing to hinder a total extraction of the value." One other chief result is that the machine which affords the best conditions for the grinding is the tubular flint mill, and that it is likely that much will be heard from the machine in the near future. Since the results obtained by Messrs. Butters and Hamilton were similarly obtained by others, some notes on recent developments and improvements in the construction of pebble mills should be of special interest.

Chemical manufacturers, makers of colors and drugs, etc., have recognized for a great many years that the pebble mill is the most economical and effective machine, when hard materials are to be reduced to a fine powder. In fact it has been found that the product of these machines contains at least 50 per cent more extremely fine particles than a similar quantity reduced in any other existing form of grinding machine.

For industries where large capacities on one class of material are desired it has become necessary to modify somewhat the design of the old pebble mill. Its successor is the modern pebble tube mill. This differs from the pebble mill, in that the material is fed into it at one end and discharged at the other, thus making it a continuous operation, the fineness of the finished product being regulated by the feed. The slower the material is fed, the longer it is subjected to the action of the pebbles and the finer the discharged product will be, whereas the faster it is fed, the coarser it will be discharged, so that a product of 100 mesh, 150 mesh or 200 mesh can be produced with the simple adjustment of the feed.

Up to the present time, the Portland Cement industry has been the largest user of the tube mills in this country, but most of this material is not reduced finer than so that 97 per cent will pass a 100-mesh sieve, but the Abbe tube mill, which will be described more in detail further below, has been used for reducing such materials as raw flint, pumice stone, feldspar, plumbago, talc, etc., to finenesses of 150, 160, 170 and

200 mesh, showing that it is well adapted to that class of work.

The tubular pebble mill has undergone considerable perfection during recent years, but had still one drawback. This was the trouble caused by the feeding and discharging mechanism of the machine. There are generally required for feeding a separate driving arrangement, stuffing boxes to stop it from leaking, the use of a conveyor, which is liable to wear out, clog up or break, while similar troubles exist at the discharge end of the tube. These troubles are avoided in the very simple and interesting "Ideal" spiral feed and discharge covered by patents granted to Mr. Max F. Abbe within the past year.

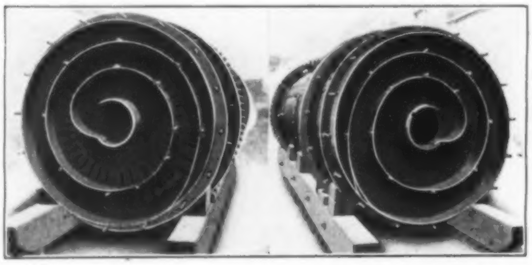


FIG. 1.—DISCHARGE END AND FEED END OF PEBBLE TUBE MILL.

The feed end is shown on the right of Fig. 1, while the discharge end is shown on the left hand. This arrangement does away with the special drive, as it is attached directly to the mill with which it revolves, requires no stuffing boxes, does away with manholes in the shell (which are always an obstruction to making a perfect lining inside of the machine), can be used to feed the pebbles into the mills, and can also be used to discharge them by simply removing the handhole plate on the outside head of the discharge end of the tube mill, taking out the one shown in the left-hand picture of Fig. 1, replacing the one on the outside head and starting the machine. The pebbles will come out through the handhole left open, be conveyed by the spiral to the center, at which point they will be discharged just like material. In this way all labor of shoveling pebbles is avoided, when, for any reason, the user desires to empty the mill completely.

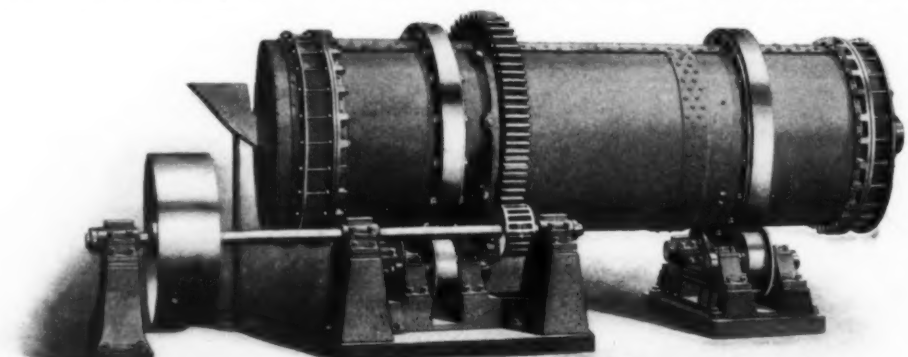


FIG. 2.—PEBBLE TUBE MILL.

The right-hand of Fig. 1 shows the feed end of the latest style machine open; over the outside surface of the spiral there is a one-inch thick plate, which is held in position by the bolts shown without nuts. This plate is perfectly flat, having an opening near its circumference, the opening ending where the spiral starts. Through this opening the material passes into the spiral and is fed to the mill. In front of this plate is fastened a wrought-iron receiving chamber, into which the material can be fed by a chute from a bin or other means convenient to the user. Fig. 2 shows this wrought-iron construction on the feed end of the machines.

The machine shown in Fig. 2 represents the most modern of the pebble tube mills built by the Abbe Engineering Company, St. Paul Building, New York City. It is stated that two of these mills, 5 feet diameter x 22 feet long, will be installed in a Colorado gold mine in the near future, and the results which will be obtained there will be awaited with great interest. The Abbe Co. has made a specialty of fine pulverization for a number of years, and are building to-day pebble mills in eight styles and thirty different sizes, thus having the most complete line of this class of machinery in the world. From their new eighty-page catalogue we note that this company has recently added a new feature to their business, which is a complete testing laboratory, where they have upwards of a dozen of their different mills constantly set up, ready to crush, cut, grind or mix, either dry or wet, any product, when interested parties desire to see the machines do their work.

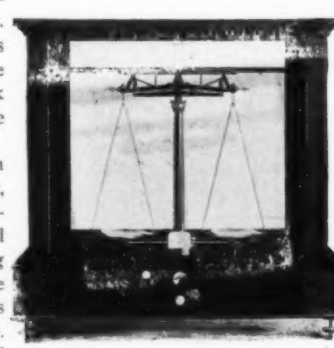
An Improved Short Beam Analytical Balance.

The accompanying illustration shows a new analytical balance just placed upon the market by Wm. Ainsworth & Sons, the well-known balance manufacturers of Denver, Col.

Among the more important improvements embodied in this balance may be mentioned the beam, which is made of hard-rolled nickel-aluminium instead of cast pure aluminium, as is usually supplied; its design such as will enable it to maintain its adjustment throughout a wide range of temperature and still have ample strength to carry 50 per cent. more than its rated load.

The rider apparatus is of improved design, and so constructed that the rider arm or carrier cannot touch the beam, and, if need be, the rider can be taken off and replaced in the dark without dropping it off the carrier or knocking it off the beam.

The hangers are of skeleton construction, similar to those used on their button balances and have a maximum carrying capacity with a minimum amount of weight.



BALANCE.

Two sensitive levels are set in the metal base in front of the index and in plain view of the operator.

The case is of French polished mahogany, with counterpoised sliding door in front and a removable sliding door in back. A plate glass sub-base covers the entire top of base. All metal work is gold plated. In the illustra-

tion the counterpoised sliding door has been removed to better illustrate the balance. A gold medal has been awarded Messrs. Wm. Ainsworth & Sons for fine balances and weights at the World's Fair, St. Louis.

Bauxite Brick.

In connection with the problem of refractory furnace lining to which we have given considerable attention in the past (especially in our November issue, 1904), a note published in *Iron Age* of December 1, is interesting. It refers to a process recently patented by W. F. Berger, for making refractory brick out of bauxite. The value of bauxite as a refractory material has been known for several years, but its lack of cohesive qualities has heretofore prevented its being molded into brick. The patent of Berger covers the use of a binder with calcined bauxite.

The new process uses a natural bauxite from Arkansas which is particularly low in silica, bonded by a small percentage of plastic fire clay. The amount of silica in the finished brick is considerably less than 10 per cent., and is not appreciably detrimental to its elasticity. The brick contains from 88 to 90 per cent. of alumina, and from 10 to 12 per cent. ferric oxide, titanic acid and silica. This brick is especially adapted for linings of basic open hearth furnaces. The highest grade bauxite brick are used in the floor and walls up to the slag line, protected by a bed of calcined bauxite. Above the slag line cheaper brick, with a lower percentage of bauxite, may be used.

The brick is now made on a commercial scale by the American Bauxite Company. The price at which it will be sold is stated to be considerably lower than that of magnesite brick and there are one-third more bricks to the ton. Severe tests have been made in several of the principal steel plants of the country which are said to have proved very successful.

A Novel Filter-Press Design.

We herewith illustrate a new type of filter-press plate, patented by the Niles-Bement-Pond Co., of 136-138 Liberty Street, New York city, which constitutes a rather radical departure from the types at present in use.

Instead of being made of cast-iron in one piece, the plate consists of a panel *A* of corrugated steel, held loosely in a groove in a cast-iron frame *B*. This frame is of sufficient depth to give the required thickness of cake. In making the frames, special precautions are taken to insure uniform thickness and true joint faces. This is accomplished by casting the frame in one piece, drilling the holes for the studs, *C, C'*, and then only parting the frame at *D, D'*. Only after this joint has been permanently made, the two joint faces of the frame are planed.

To carry away the clear liquor, a drainage groove *E* is formed in the bottom member *F* of the frame, which opens into an outlet port *G*, provided, as usual, with a nozzle or cock.

The advantages claimed for this method are the following: A much deeper groove can be employed with the steel panel than is possible with a cast-iron plate, without making the latter excessively thick. Consequently, the area of free filter cloth is much larger, as is also the cross-section of groove behind it, the result being more rapid filtration and better drainage of the clear liquor. The latter is still further improved by the method of carrying off the filtrate. It will be noticed in the plan and cross-section of the plate, that the grooves of the steel panel open directly and to their full cross-section into the drainage groove *E*. This outlet passage cannot be obstructed by the sagging of the filter cloth, as in a cast-iron plate, where it is formed on the surface of the plate.

One of the greatest advantages is the very considerable reduction in the weight of the plates, the saving amounting to about 50 pounds on the 24-inch square, and about 100 pounds on the 32-inch square plate. The price of the plates is correspondingly lower, while freight charges, labor in handling, and risk of breakage are all much reduced.

Panel plates are much more easily cleaned than cast-iron plates, and any scale formed on them may be removed by

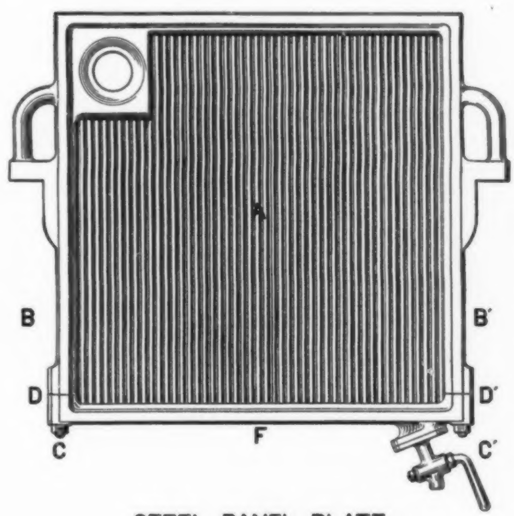


FIG. 1.—FILTER PRESS PLATE.

tapping. For the filtration of hot liquors, the steel panel plate is also much superior to cast plates. The latter often break in consequence of the central part of the plate expanding more rapidly than the tightly held rim. The steel panel is only loosely held in its frame, and is thus free to expand without causing any trouble. In case of damage to a plate by unequal pressure, such as is sometimes caused by the blocking of the feed channel to a chamber, only the steel panel is rendered useless. With cast-iron plates, which, just like the

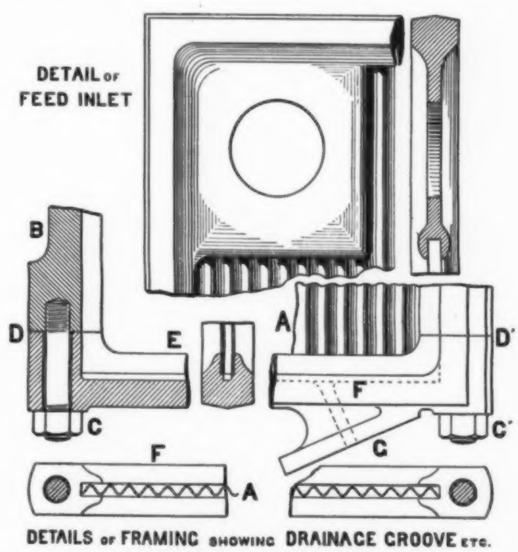


FIG. 2.—DETAILS OF PLATE CONSTRUCTION

panel plates, cannot be made strong enough to resist pressure, applied to one side only, a broken plate is entirely lost, the damage amounting from five to ten times the cost of a new corrugated panel

The feed inlet in the illustration is shown in one corner, in a lug of the cast-iron framing, but it may also be placed in the center, as in cast-iron plates. These steel panel plates are made in all sizes from 18 inches to 36 inches square, and in all usual types, non-washing and washing, with open or closed deliveries.

Pyrometers Suitable for Metallurgical Work.

(*Concluded from Vol. II., page* 510.)

5. *The Siemens Electric Pyrometer* (made by Messrs. Siemens Brothers & Co.).—The Siemens electrical pyrometer is a platinum resistance thermometer which has a coil of platinum wire wound upon a cylinder of refractory material, and fixed usually at the end of a long closed iron tube where it is protected by a platinum shield. To measure in actual practice the resistance of the coil and thus its temperature, two types of apparatus are employed. One of these, comprising a differential galvanometer and a set of resistance coils, gives readings in ohms, from which the temperatures are ascertained by means of special tables. The other is a combination of a small D'Arsonval galvanometer and a Wheatstone bridge of circular form with sliding contact, and gives readings directly in thermometric degrees. The first of these types is an instrument of great accuracy, and its determinations can be relied upon to agree within a fraction of 1 per cent with those of an air thermometer. It is very simple in its arrangement and working, and may be entrusted to the care of any intelligent workman. It finds special application in works where it is necessary to ascertain from time to time the heat of furnaces, flues, etc., particularly those in which the processes demand the maintenance of a definite temperature during certain operations. It is employed in most of the principal steel works in the United Kingdom and on the Continent for determining temperatures during the manufacture of steel plates.

Fig. 1 is a diagram showing the pyrometer and galvanometer with resistance coils and battery connected up for taking a reading. The galvanometer is placed with its needle pointing to zero and the end of the pyrometer tube is inserted in the furnace the temperature of which is to be measured, the upper part of the tube being protected from the heat by fireclay or a sheet of iron. When the tube is thought to have acquired the temperature of the furnace, the key marked K is pressed down, causing the battery current to divide at the back of the key into two circuits, one of which includes one coil of the galvanometer and the pyrometer coil, while the other includes the other galvanometer coil and the resistance box. If the resistance of the pyrometer coil does not equal that of the circuit of the resistance box, the needle is deflected, and in order to establish a balance the holes in the resistance boxes must be plugged or unplugged, until the galvanometer needle returns to zero. The sum of the unplugged whole numbers of the resistance box, plus the decimal marked opposite the hole filled by the traveling peg, will then give the resistance of the pyrometer coil in ohms. In order to take a reading, the traveling peg connected with the terminal R^1 is inserted in the hole marked *o*, and the resistance between the fixed terminals T and *o* is unplugged until the galvanometer is balanced as nearly as possible, while the key K is continuously depressed. The traveling peg is then moved along the decimal coils of the resistance box until the point is reached when the galvanometer needle remains exactly at zero and the unplugged resistance between terminals T and *o* is then read off plus the decimal indicated by the traveling peg. The resistances between the terminals T and *o* are additive, while the decimal parts progress by 0.05 ohm from 0 to 1 ohm. Thus, if the holes 1, 2, 4 and 20 are unplugged, and the traveling peg is in the 0.65 hole, the resistance of the coil will be 27.65 ohms. The length of the wires A and B connecting the galvanometer to the pyrometer tube does not affect the reading so long as the wires are of equal resistance, as their resistances vary equally with variations of temperature and balance one another.

The second type, or direct-reading apparatus, comprises a Wheatstone bridge, one limb of which is an adjustable resistance formed out of a helical coil of wire arranged round the edge of a circular dial. The dial is divided into either Fahrenheit or Centigrade degrees as desired, and in the center of it is a small D'Arsonval galvanometer, a type of instrument unaffected by external magnetic fields. A sliding contact with a pointer serves to adjust the resistance of the variable limb of the bridge, and at the same time to indicate on the dial the temperature of the coil when the balance has been obtained.

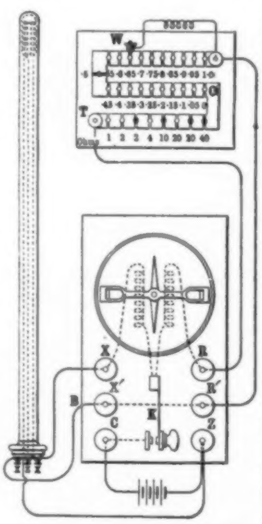


FIG. 1.—SIEMENS PYROMETER.

The keys are combined and fitted to the arm of the sliding contact in such a way that by depressing the knob of the contact the battery is put into circuit with the galvanometer and pyrometer. The whole is mounted upon a tripod stand. To take a temperature, the pyrometer is connected by means of a three-cored cable to three of the terminals and the battery to two terminals of the instrument. The sliding arm is moved to some point on the scale and the lever depressed until the point is found at which the depression of the key produces no deflection of the needle of the galvanometer. The pointer attached to the sliding contact will then indicate the temperature of the pyrometer coil. This type of instrument is quite as sensitive as the first type described, and it possesses a great advantage in avoiding the inconvenience and liability to error arising from the use of conversion tables. There is, moreover, only one piece of apparatus to be handled instead of two, and, unlike the other, it is not affected by external magnetic fields due to the proximity of dynamos or powerful electric currents, while its manipulation is even more simple.

The WESTINGHOUSE ELECTRIC & MANUFACTURING CO. has closed a contract with the Ontario Power Company for an alternating current generator with a rated output of 10,000 hp., at 85 per cent power factor. This is in addition to three other machines of similar type, which the Westinghouse Co. is furnishing for this plant. The generators are of the revolving-field, two-bearing type, designed for direct connection to water-wheels; they generate three-phase current at 12,000 volts and 25 cycles, and run at a speed of 187½ r. p. m. Among other apparatus included in the contracts are twelve 3000-kw. oil-insulated, water-cooled transformers, wound for 12,000 and 60,000 volts; two 375-kw. exciters, and complete switchboards. The plant is being built by the Niagara Construction Company.

Largest Electrical Generators in the World Driven by Gas Engines.—The California Gas & Electric Corporation, San Francisco, Cal., has just placed an order with the CROCKER-WHEELER CO., Ampere, N. J., for three 4000-kw., three-phase, 13,200-volt, 25-cycle, 88-r. p. m., revolving-field, alternating-current generators, to be driven by 5400-hp. gas engines built by The Snow Pump Co. These generators are the largest in capacity in the world driven by gas engines, and will furnish power for operating all the street railways in San Francisco and vicinity. The alternating-current machinery of the Crocker-Wheeler Company is of the design of Brown, Boveri & Cie., the celebrated Swiss electrical engineers.

St. Louis World's Fair.

In former issues, and especially in our last September number, we have given illustrated descriptions of those exhibits which should be specially interesting to our readers. The following notes and illustrations are supplementary to our former articles. The exhibits of the Goldschmidt Thermit Co., and of the Roessler & Hasslacher Co., illustrations of which are given below, are described on page 376 of our volume II.

SOCIETE ELECTRO-METALLURGIQUE FRANCAISE.

This company was formed in 1888 for the manufacture of aluminium by the Héroult process. The company has works at Froges and LaPraz. Besides aluminium, the chief products of the company are steel and ferro-alloys, made in the Héroult electric furnace, and it is with respect to these products that the exhibit of this company was specially interesting.

Dr. Héroult's work in this line has been noticed in our columns repeatedly at length, with descriptions of his various types of furnaces, so that we may record here only the principal features of the exhibit. The wide range of steel of different qualities which can be produced by the Héroult process, was well illustrated by two samples of extreme grades exhibited—namely: one of extra mild quality, containing traces only of carbon; and another with a high percentage (4.07) of carbon, this high yield in carbon being obtained by liquid carbonization in the electric furnace. These two extreme grades, together with the various other qualities shown, were manufactured in the Héroult oscillating electric furnace, a model of which, on a reduced scale, was shown in the center of the exhibit.

By starting a heat with low quality material, steel is produced commercially in the electric furnace containing 0.005 to 0.015 phosphorus; 0.005 to 0.020 sulphur; any desired percentage of carbon from 0.01 to 4 per cent, any desired percentage of silicon and manganese, and any desired percentage of chrome, tungsten, etc.

The specimens of castings exhibited were not given as illustrating perfect foundry practice; some of these specimens, however, were interesting in that they showed that the manufacture of castings of extra mild steel (pure iron), perfectly sound notwithstanding the small thickness, ⅛ inch in the specimens exhibited, is a very easy matter. The ordinary class of cast-iron articles were used as patterns in the moulding of those shown in the exhibit. A cast plate, exhibited 3-16 inch in thickness, was also of extra mild steel. A bell was a specimen of a steel casting, the steel containing about 1 per cent of carbon. The carbon steel obtained by the Héroult process is said to be easy to work either cold or hot; it welds readily, tempers well, and can be annealed and tempered repeatedly without deteriorating. Numerous specimens of ingots obtained by the Héroult process, containing various percentages of carbon, were displayed. They were broken to show the homogeneity of the metal and its soundness. These ingots were chosen to illustrate the variety obtained in the brands, from iron containing 0.02 per cent of carbon to the specimen of highly carburized steel containing over 4 per cent. There were exhibited also, grouped together to form two pillars, sample bars of various brands of carbon tool-steel, chrome steel bars, a bar of special steel for chisels, etc. The show-cases contained besides, numerous broken and bent test pieces.

Samples of ferro-chrome, ferro-silicon, ferro-nickel and ferro-tungsten, and of white and gray pig iron, made in the electric furnace, were also exhibited; also some samples of copper matte, produced at LaPraz in the electric furnace from a silicious attle ore containing about 6 per cent of copper. The matte yields approximately 40 per cent copper.

SOCIETE ANONYME ELECTROMETALLURGIQUE PROCEDES PAUL GIROD.

The exhibit of this company consisted of samples of electric furnace products, especially ferro-alloys, such as ferro-silicon, ferro-titanium, ferro-chrome, ferro-nickel-silicon, also tungsten steel and vanadium steel.

CHEMICAL EXHIBITION OF GERMAN GOVERNMENT.

This very interesting exhibition, arranged under the auspices of the German Government, was intended to give an historical outline of the development of chemical science and industries in Germany. The following societies had contributed exhibits: The German Chemical Society, the Society for Protecting the Interests of the Chemical Industry of Germany, the Society of German Chemists, the German Bunsen Society, besides manufacturers of chemical instruments and apparatus. Besides thirty-nine chemical manufacturers and twenty-five makers of chemical apparatus, 117 professors and instructors of universities were represented by exhibits.

The exhibition was divided into eleven departments, namely, a reading room, an alchemistic laboratory, Liebig's laboratory, exhibits of general and inorganic chemistry, pyrochemistry, balances, electrochemistry, organic chemistry, dyeing laboratory, and physiological chemistry.

The electrochemical department was specially interesting for a great many instruments exhibited, among them the historical apparatus by which Kohlrausch made his classical researches on conductivities of solutions; various apparatus of Ostwald; a complete arrangement of working desks with instruments, etc., for electrochemical researches, the arrangement being the same as in the electrochemical laboratory of the University of Goettingen; apparatus of Classen for quantitative analysis for electrolysis; and apparatus of the Vereinigte Fabriken für Laboratoriumsbedarf (New York branch, Laboratory and School Supply Co.) for demonstrating electrochemical processes and laws.

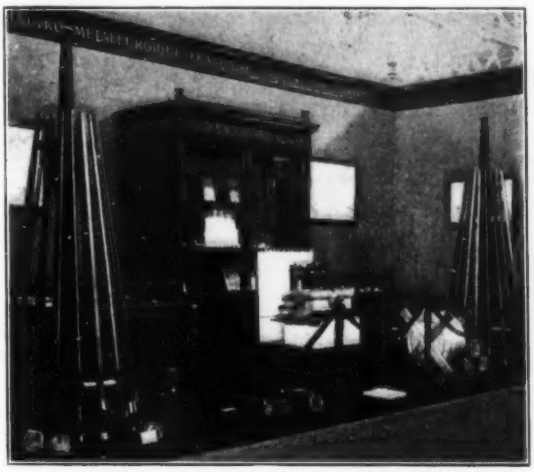


EXHIBIT OF ELECTRIC STEEL, HEROULT PROCESS.

There was also exhibited a Siemens & Halske ozone apparatus, while the Hofman Haus in Berlin, Prof. Ost and Prof. Elbs had contributed a collection of electrochemical products.

THE WESTINGHOUSE STEAM TURBINE.

A memorable incident of the morning following the close of the St. Louis Exposition was the formal shut-down and inspection of the 600-hp. Westinghouse steam turbine generating unit in the Palace of Machinery, after a continuous run of over 3962 hours—a performance which has had no parallel in steam turbine history. During the five and a half months that the unit was in operation it supplied current for light and power throughout the Westinghouse exhibits in the Palaces of Machinery, Electricity and Transportation. When the machine was stopped, it was found to be in perfect condition, and there were no signs of wear, the bearings still retaining the tool marks as they had come from the shops. There have been at

least two instances on record in America in which piston engines have been run continuously for about the same length of time as that of the record run of the Westinghouse turbine. The remarkable feature of the turbine run, of course, was the maintenance under load of a speed of 3600 revolutions a minute for such a long period. From

ALCHEMISTIC LABORATORY IN GERMAN CHEMICAL EXHIBITION.

8.30 o'clock in the morning to 10.30 o'clock in the evening, the load carried throughout the Exposition varied from 25 per cent underload to 25 per cent overload. The total number of revolutions almost touched the billion mark—855,792,000.

Storage Battery Locomotive.

In the court of the Palace of Electricity there was an exhibit and demonstration of an "industrial" railway and locomotive, the design of the C. W. Hunt Co., of West New Brighton, S. I., N. Y. The locomotive was of the narrow-gauge electric storage battery type, and was especially designed for use with "industrial" railways in machine shops, factories, storage yards, smelting and refining plants, steel works, shipbuilding yards, wharves, plantations, lumber mills and wherever it is designed to handle economically, material from one part of a plant to another. The gauge of the road at the exposition was 21½ inches, which is the standard of the "industrial" railroads built and laid by the C. W. Hunt Co., and with which it is possible to operate around curves of 12 feet radius, thus enabling any part of the works of a factory to be reached, a matter of importance for manufactories with irregularly placed buildings. The locomotive carries a storage battery which furnishes power to two independent motors. There are eight driving wheels to the locomotive, and the design is such that all of the wheels are used as drivers, thus securing a maximum tractive effort and a duplication of mechanism. The motors are made by the Westinghouse Electric Co., their electrical efficiency being high.

In the Electricity Building the company was exhibiting a straight-line electric hoist, together with photographs of plants which have been equipped with their coal-handling machinery, a line of manufacture in which the company was the pioneer.

Awards.

Among the prizes awarded to exhibitors were the following:

Machinery Building. Grand Prizes.—Allis Chalmers Co., Chicago; General Electric Co., Schenectady, N. Y.; Goldschmidt Thermit Co., New York; A. Leschen & Sons Rope

LIEBIG'S LABORATORY IN GERMAN CHEMICAL EXHIBITION.

Co., St. Louis; Lidgerwood Manufacturing Co., New York, Niles-Bement-Pond Co., New York; Robbins Conveying Belt Co., New York; Westinghouse Machine Co., Pittsburg, Pa.; R. D. Wood & Co., Philadelphia, Pa.; Henry R. Worthington, New York.

Gold Medals.—Buffalo Forge Co., Buffalo, N. Y.; Builders' Iron Foundry, Providence, R. I.; A. S. Cameron Steam Pump Co., New York; Carborundum Co., Niagara Falls, N. Y.; Dearborn Drug & Chemical Company, St. Louis; De Laval Steam Turbine Co., Lombard Governor Co., Boston, Mass.;

EXHIBIT OF GOLDSCHMIDT THERMIT CO.

Lunkenheimer Co., Cincinnati; Aug. Mietz, New York; Mietz & Weiss, New York; Norton Emery Wheel Co., Worcester, Mass.; Otto Gas Engine Co., Philadelphia; Weber Gas & Gasoline Engine Co., Kansas City, Mo.; Société De Laval, Paris, France.

Mines and Metallurgy. Grand Prizes.—E. G. Acheson, Niagara Falls, N. Y.; Allis-Chalmers Co., Chicago, Ill.; American Coal Products Co., New York; Austin Manufacturing Co., Chicago, Ill.; Baker & Co., Newark, N. J.; Bethlehem Steel Co., South Bethlehem, Pa.; Canadian Copper Co., Sudbury, Ontario; Dubois, Pinard et Cie., Sougland, par Saint-Michel, Arsne.; Goldschmidt Thermit Co., New York; Inter-

national Acheson Graphite Co., Niagara Falls; International Nickel Co., New York; Julian Kennedy, Pittsburg, Pa.; Koenigliche Porzellan Manufaktur, Berlin, Germany; Lanyon Zinc Co., St. Louis, Mo.; A. Leschen & Sons Rope Co., St. Louis, Mo.; Manganese Steel Safe Co., New York; Morgan Construction Co., Worcester, Mass.; Northwestern Terra Cotta Co., Chicago, Ill.; Norton Emery Wheel Co., Niagara Falls, N. Y.; Pittsburg Reduction Co., Pittsburg, Pa.; Société Electro-Metallurgique Francaise de Froges, Froges, Isere; Solvay Process Co., Syracuse, N. Y.; Taylor Iron and Steel Co., High Bridge, N. J.; Tiffany & Co., New York; Worth Brothers' Co., Coatesville, Pa.

Gold Medals.—William Ainsworth & Sons, Denver, Colo.; American Concentrator Co., Joplin, Mo.; Baker & Co., Inc., Newark, N. J.; Baldwin Locomotive Works, Philadelphia, Pa.; C. O. Bartlett & Sons Co., Cleveland, Ohio; Cyrus Borgner, Philadelphia, Pa.; F. W. Braun & Co., Los Angeles, Cal.; Carborundum Co., Niagara Falls, N. Y.; Colorado Iron Works, Denver, Colo.; Sherard Cowper-Cowles & Co., London, England; Crawford & McCrimmon Co., Brazil, Ind.; De Laval Steam Turbine Co., Newark, N. J.; Denver Fire Clay Co.,

EXHIBIT OF THE ROESSLER & HASSLACHER CO.

Denver, Colo.; Eimer & Amend, New York, N. Y.; Charles Engelhardt, New York; Arthur Fritch Foundry & Milling Co., St. Louis, Mo.; General Electric Co., Schenectady, N. Y.; Granbury Smelting & Refining Co., St. Louis, Mo.; Aug. Gundlach, Joshua Hendy Machine Co., San Francisco, Cal.; Hinque, Marret et Bonnain, Paris, France; Hohman & Maurer Manufacturing Co., Rochester, N. Y.; Keuffel & Esser, New York; Laclede Fire Brick Co., St. Louis, Mo.; Lidgerwood Manufacturing Co., New York; Louisville Fire Brick Co., Louisville, Ky.; Missouri Fire Brick, St. Louis; National Lead Co., St. Louis, Mo.; Primos Chemical Co., Primos, Pa.; Robins Belt Conveying Co., New York; Salt Lake Hardware Co., Salt Lake, Utah; Schoellborn-Albrecht Machine Co., St. Louis; Siemens-Halske Co., Berlin; Société Anonyme Electro-Metallurgique D'Albertville, Savoie, France; Robert M. Thompson, New York City; Trenton Iron Co., Trenton, N. J.; Western Carbonic Gas Co., Sacramento, Cal.; Western Gas Construction Co., Fort Wayne, Ind.; Wetherill Separator Co., New York City; Jos. Wharton, Philadelphia, Pa.; Wilson Aluminum Co., Holcomb, Va.; Williams Patent Crusher & Pulverizer Co., St. Louis, Mo.; R. D. Wood & Co., Philadelphia, Pa.

Liberal Arts Building. Grand Prize.—The Roessler & Hasslacher Co., New York.

Manufacturers and Varied Industries Building. Grand Prize.—Carborundum Co., Niagara Falls, N. Y.

The official list of the awards in the Electricity Building has not yet been published.

Industrial Notes.

The plant of the J. T. Baker Chemical Co., of Easton, Pa., is nearing completion. This plant comprises several buildings located on the outskirts of Phillipsburg, N. J. The intention of the company is to manufacture strictly c. p. acids and chemicals for analytical and laboratory use. J. T. Baker, formerly of the Baker & Adamson Chemical Co., is president of the concern. It is expected to have the plant, or at least part of it, in operation some time during this month.

The Power & Mining Machinery Co., of Cudahy, Wis., has just issued bulletin C1 on the Holthoff revolving hearth roasting furnace. This is built in four different types. Type A is designed for roasting low sulphur ores, preparatory to chemical treatment, and is built with a centrally located gas producer. Type B is designed for the same purpose, and is similar to type A, except that a plain fire-box is substituted for the gas producer. Type C is designed for roasting sulphide ores preparatory to smelting. Type D is designed especially for roasting pyritic ores without the use of fuel other than sufficient to ignite the sulphur. The pamphlet describes the special features of the four various types and their general construction, and is neatly illustrated.

Mr. E. R. Taylor, president of the Taylor Chemical Co., of Penn Yan, N. Y., reports for the month of December, 1904, the largest monthly output of bisulphide of carbon he ever had. Mr. Taylor's electric furnace was described in our Vol. I., pages 60, 63, 76 and 568.

Personal.

Messrs. FitzGerald and Bennie, of Niagara Falls, have become the American associates of the Société Anonyme d'Etudes Electrochimiques, of Geneva, Switzerland.

The many friends of Mr. Alois von Isakovics, the well-known secretary of the New York section of the American Electrochemical Society, will be glad to hear that he is now almost completely restored to health, and has started in business at Monticello, N. Y., under the firm name of Synfleur Scientific Laboratories.

Mr. C. J. Pretzfeld, formerly of the Niagara Research Laboratories, is now associated with the People's Gas Light & Coke Company, of Chicago.

Mr. Woolsey McA. Johnson has resigned his position as metallurgist of the No. 2 works at Iola, Kansas, of the Lanyon Zinc Company, and head of the laboratory for metallurgical research at La Harpe. Mr. Johnson expects to be in New York for some time.

Mr. Jacob Langeloth, president of the American Metal Company, New York, has been elected president of the Granby Consolidated Mining, Smelting & Power Company of British Columbia.

Almanacs.

The *Westinghouse Electric and Manufacturing Co.* has issued a very useful diary for 1905, neatly bound in black leather. Besides the pages ordinarily contained in a diary, and several small maps of the United States and its foreign possessions, the little book contains carefully selected information on various subjects of timely interest and usefulness for electrical and mechanical engineers, the data given being based on the latest and best practice. The subjects dealt with are electric railways (train resistance, electric car heating, drop in line and rails, single-phase traction); electric motors for machine tool drive (lathes, boring mills, drill presses, milling machines, slotters, shapers, planers, power pressers); electric illumina-

tion (Nernst lamps, Cooper-Hewitt lamps, arc lamps); power transmission (line loss, alternating-current formulæ, wire table); convenient formulæ, lightning arresters and choke coils (low equivalent arresters, multi-path arresters, alternating or direct-current circuits); "sparks;" operating hints on electrical machinery; first aid to the injured; steam boilers and heating value of coal; commercial power gases; gas engines, performance curves; steam turbines, performance curves. The handsome diary should prove very useful on the desk, as well as in the pocket of engineers.

The *Pope Bicycle Daily Memorandum Calendar* for 1905 is a desk calendar containing a memorandum leaf for every day in the year and 365 original sayings in favor of good roads, good, healthy out-door exercise and the modern bicycle, by a great many prominent men. Dr. Ira Remsen, of Johns Hopkins, writes: "If anything I can say or do will help spread the proper use of the bicycle, I shall be glad to say or do it, for I feel that the bicycle is one of the best friends mankind has ever had." Prof. Elihu Thomson says: "Good roads are an important asset in national wealth. The bicycle has been, and it is hoped may continue to be a potent cause of this great sentiment leading finally to the nation's enrichment." Dr. Charles S. Palmer, now one of the editors of the *Engineering and Mining Journal*, writes: "A good thing may be measured by the variety and quality of its benefits—to the one and to the many. Time, health, happiness—that is the measure of a good wheel on a good road." The calendar is free at the Pope Manufacturing Company's stores, or any of our readers can obtain it by sending five two-cent stamps of the Pope Manufacturing Co., Hartford, Conn., or 143 Sigel Street, Chicago, Ill.

Digest of U. S. Patents.

PRIOR TO JULY, 1902.

Compiled by Byrnes & Townsend, Patent Lawyers, National Union Building, Washington, D. C.

MOLTEN ELECTROLYTES, MISCELLANEOUS.

(*Continued from Vol. II., page* 518.)

610,014. August 30, 1889. Heinrich C. Aschermann, Cassel, Germany.

Reduces refractory oxides as the oxides of chromium and aluminium, and produces the metals free from carbon by employing as a flux and reducing agent sulphide of antimony. The reaction occurs according to the following equation:

$$10Cr_2O_3 + 23Sb_2S_3 = 20Cr + 46Sb + 15SO_2 + 54S.$$

The mixture to be reduced is placed in an iron vessel connected as the cathode, an anode of carbon being centrally inserted. The E. M. F. is in all cases kept at the practicable minimum. The antimony is separated from the chronium by volatilazation.

618,575. January 31, 1899. Farnham Maxwell Lyte, London, England.

Treats complex sulphides of zinc, lead and silver by grinding, calcining at low redness to convert zinc sulphide to sulphate, which is leached out. The equivalent quantity of sodium or calcium chloride is added to the previously neutralized lixiviate forming zinc chloride from which the alkaline sulphate is separated by refrigeration. The zinc chloride solution is evaporated and dehydrated with production of some zinc oxide by heating it in contact with molten zinc. The oxidation of the zinc is accelerated by alloying it with antimony to form a galvanic couple, or by associating it with carbon. The anhydrous fused zinc chloride containing zinc oxide in solution and suspension is electrolyzed above a cathode of molten zinc. The vessel is of iron, the sides being lined with firebrick set in china clay, powdered pumice or silica sand and water glass, and the bottom being covered by a layer of silicated asbestos cardboard or fire clay. Carbon conductor to the cathode is enameled. Carbon anodes with enlarged ends perforated for escape of chlorine. The molten zinc is removed through a siphon tap.

641,438. January 16, 1900. James D. Darling, Philadelphia, Pa.

Apparatus for the electrolysis of hydroxides or nitrates of the alkali metals, employing a diaphragm of concentric perforated metallic walls, the interspace being filled with particles of vitrified magnesia as described in patent 590,826. The inner wall of the diaphragm is preferably of double thickness. The cathode is within the inner cup and the anode of cast iron surrounds the diaphragm. In order to protect the metallic walls of the diaphragm against local action, a portion of the current, say 5 per cent., is shunted to these walls, the shunt being connected through a suitable resistance with the anode lead.

642,390. January 30, 1900. Frank P. Van Denbergh, Buffalo, New York.

Sulphuric acid is produced by the electrolysis of melted gypsum in an oxidizing atmosphere and in presence of a suitable silicious flux, such as sand, quartz, clay, etc. The oxidizing atmosphere may be obtained by mixing hematite iron ore with the charge, or by injecting steam, air, or oxygen. Preferably steam is injected in sufficient proportion to oxidize the sulphur dioxide and to hydrate the resulting trioxide. A continuous furnace is described having lateral electrodes of carbon, and a siphon tap for the calcium silicate slag. Continuous charging devices are described, and the gaseous products are removed by a steam jet. It is claimed that the acid is free from impurities, particularly from arsenic.

642,933. February 6, 1900. Oscar J. Steinhart, Julius L. F. Vogel, and Henry E. Fry, London, England.

Produces zinc by electrolyzing a molten solution of zinc oxide in zinc chloride, to which may be added a small amount of sodium chloride. The cell is a rectangular pan of refractory material placed over furnace flues. The cover of the pan consists of a series of transverse carbon blocks having depending portions constituting the anode. The cathode is a layer of zinc about 1 inch deep on the bottom of the pan and maintained at a temperature just above its melting point. The bath floating on the zinc is about two inches deep. The zinc chloride is preferably obtained by evaporating and dehydrating zinc chloride in a partial vacuum. The voltage is 3. The zinc is withdrawn through a siphon tap and fresh oxide is added as required.

669,271. March 5, 1901. Frank P. Van Denbergh, Buffalo, New York.

Produces phosphoric acid by electrolyzing a molten mixture of apatite and a silicious flux such as sand, clay, etc., an oxidizing atmosphere being maintained above the bath to convert the phosphorous which is freed and volatilized into the pentoxine. This oxide is then hydrated as by the introduction of steam. The oxidizing atmosphere contains an excess of free oxygen which may be supplied by hematite ore, steam, oxygen, ozone, etc. The fused slag runs out through a siphon tap. The apparatus is that of patent 642,390.

677,906. July 9, 1901. Frank P. Van Denbergh, Buffalo, New York.

Produces alkali silicates by electrolyzing a molten mixture of an alkali chloride and a silicious flux such as silica feldspar, etc., in the presence of an atmosphere containing an excess of oxygen which may be supplied by iron oxide, manganese oxide, an alkali sulphate or nitrate, water, steam, oxygen or ozone. The preferred bath is sodium chloride containing a small amount of potassium chloride to lower the melting point. The sodium chloride should be in amount from two to four times that of the silicious flux. The preferred apparatus is that of patent 626,373. Steam or air is projected into the furnace to oxidize and hydrate the molten mass. The molten silicate or mixed cilicates flow out into a tank containing water and may be treated with carbon dioxide to produce sodium carbonate and hydrated silica; or milk of lime may be added to produce calcium silicate and caustic soda or potash.